HANDBOOK
OF
MUSEUM TECHNIQUE

EDITED BY
A. AIYAPPAN, M.A., Ph.D. (Lond.)
(Formerly Superintendent, Madras Government Museum)
AND
S.T. SATYAMURTI, M.A., D.Sc., F.Z.S. (Lond.)
(Formerly Superintendent, Madras Government Museum)

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CONTRIBUTORS :

Zoology
S. T. SATYAMURTI, M.A., D.Sc., F.Z.S.

Botany & Geology
M.S. CHANDRASEKHAR, B.Sc., F.B.S.,

Numismatics
P. N. MOHAN DAS, M.A.,

Archaeology
P. R. SRINIVASAN, M.A.,

Anthropology
C. J. JAYADEV, M.A., L.T.

Chemical Conservation
R. SUBRAMANIAN, M.A., F.I.I.C.

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EDITORS' NOTE.

This *Handbook* has been prepared to meet a definite need for a reference book for teachers interested in building up school museums. The teachers and several headmasters undergoing training every year at the Madras Museum in museum technique were thus responsible for the immediate stimulus for the preparation of this publication. We hope they and other teachers would find the *Handbook* useful. The annual training course in museum technique at the Madras Museum became possible on account of the interest taken by the Government of Madras and also by successive Directors of Public Instruction—Sri D. S. Reddi, Srimathi O. C. Srinivasan, Sri S. Govindarajalu Naidu and Sri N. D. Sundaravadivelu—in the educational activities of the Madras Government Museum. To all of them, we should like to express our grateful thanks. Though the *Handbook* was planned and its outline drawn up by the editors, the actual writing of the various sections of it has been the work of the curators of the scientific departments of the Museum. Originally the book was intended to serve the needs of the organizers of school museums, but as the writing progressed, we thought its scope could be somewhat enlarged so as to make it useful to curators of small museums without specialists on their staff to undertake conservation, etc. Knowing that there are a number of such museums in this country, we have very little doubt that museum curators will derive considerable benefit by using this *Handbook*.

EDITORS.

GENERAL INTRODUCTION.

Museums originally were meant to be of use primarily for specialists. The research material collected over years were not exhibited in a manner to facilitate popular education or instruction. The didactic object has now become more important and with this end in view more attractive display is attempted in all progressive museums. To illustrate an idea is now more important than to show comprehensive collections. Exhibits are displayed to stimulate thinking and questioning. The museum worker in India along with other groups of educators would like to develop a scientific attitude of mind in the masses of those who have acquired the habit of visiting museums.

To-day the Government of India and the State Governments are interested in fundamental education to help people who have not had access to formal schooling to understand and solve their immediate problems by their own efforts. As illiterate adults cannot be educated through the written word, substitute methods have to be found for their education through visual aids. Here museums come in as institutions of great utility. Methods of communication which museums have been developing for decades can easily be adapted for fundamental education.

Without our being aware of it, progressive museums have changed their roles. They are no longer store houses of curious objects which really interested a small percentage of visitors and mildly amused or 'bored' the rest. "Museums in many countries" says a UNESCO pamphlet "can no longer be considered sanctuaries for the connoisseur or specialist. They are actively engaged in revising exhibition policies and relations with the public at large and play a more important role in general education."

In the Madras State, the educational authorities have long recognised that teachers and students could gain a great deal by visits to the museums. From about 1910, the Museum staff used to conduct students from city schools round the galleries of the Museum and popular lectures based on Museum material given by the staff of the Museum were arranged periodically. As the number of schools increased, this service could not be performed adequately by the limited staff of the Museum. From about 1930 onwards the teachers of the schools of the City of Madras

were invited to make a general study of fifteen hours duration) of the galleries of the Museum with the help of the Qurators of the various sections. With the greater knowledge gained by this contact with the exhibits, the teachers were themselves expected to take their pupils on conducted visits of the Museum.

From 1949 onwards, in addition to the fifteen-hour demonstration course, we organized a somewhat intense though short course in museum technique for teachers of the State. This has been now included in the Second Five-Year Plan of the State Education Department. This book is intended primarily for the use of the teachers undergoing the course at the Museum. It is our hope that all good schools will have small museums of their own through the joint efforts of the teachers and students.

The usefulness of educational museums may be briefly stated as follows, as a recent writer has done:—

(*a*) It conveys to the children a greater number of facts in less time than if these were conveyed through words; the information about them can be more easily assimilated by the children.

(*b*) A number of facts can be presented simultaneously and the relation between them can be presented with clearness.

(*c*) The teacher and pupil can co-operate in the process of learning.

Impressions obtained in childhood are most vivid and lasting, and to the child's mind, knowledge is most welcome when its acquisition is flavoured with entertainment. The best educational museums therefore provide information to the children in the most attractive form. Children are everywhere admitted free and no pains are spared to make them feel at home in the museum. To make the museum mean the most possible to the child, it has been found advantageous to organise loans of portable exhibits of various categories for use in class rooms. Most of the larger museums of the United States of America have special departments of education which prepare and circulate enormous quantities of material to the schools of the area served by them. School Extension Service has come to be established as part of most museums in the United States of America including even the most conservative ones such as the Metropolitan Museum.

The more progressive museums in Great Britain and the United States of America also organize leisure time activities for the children. For example, the British Museum (Natural History) has a Junior Naturalists' Club for children of 10-14 years of age, a Field Observers' Club for children of 14 years and upwards, and also publishes a magazine called " The Field Observer " edited by the club members. In another very popular museum in East London, namely, the Greffrye Museum, the children visiting it on Saturdays and school holidays participate in a number of activities based directly upon the museum exhibits and involving drawing, colouring, cutting-out, assembling information, using puzzles and games, painting, modelling, puppetry, pottery, model-making, etc. Educational motion pictures, lectures and demonstrations for the entertainment and instruction of children are provided throughout the year. Several museums in the United States of America run a very large number of clubs and classes for children. The Rochester Museum of Arts and Science, one of the latest and also the most popular of museums in the New York State (with which I am connected as one of its foreign Fellows) has under its roof about 17 or 18 clubs such as the Rochester Rose Society, Rochester Aquarium Society, Cat Fanciers' Club, Cage Bird Club, Writers' Club, Dahlia Society, Amateur Radio Association, Philatelic Association, Numismatic Association, Print Club, Gladiolus Society, Needlecraft Club, Rabbit Breeders' Association, Men's Garden Club, etc. The American Museum of Natural History, New York, and a few other very large museums in the United States of America have their own broadcasting stations giving regular educational programmes intended for school-going children. The Cleveland Museum of Natural History has shown commendable enterprise in extending its educational influence to a much larger public than habitual museum visitors. Through the courtesy of the American broadcasting station, W.E.W.S., it is now presenting a monthly television programme called " Your Museum of Natural History ". Two general programmes already televized are, one dealing with the timely subject of the Navaho Indians and the other with the recent gift to the Museum of the works of John J. Audubon. including the famous early nineteenth-century English prints of Havell. There is also a regular weekly television programme built round the museum's explorers' clubs for children; subjects so far presented include the

Apache Indians, fur-bearing mammals, care of pets, bird migration and signs of spring.

The UNESCO has a division at Paris called the Division of Monuments and Museums which aims at improving the standards of museum work through international conferences and discussions and technical aid, and the preservation from war risks of cultural objects and monuments all over the world; and this Division publishes a very high class journal entitled " Museum " which acts as a forum for the exchange of ideas concerning museums on an international scale. A technical association called the International Council of Museums, also functions in Paris and closely collaborates with the Monuments and Museums Division of the UNESCO. The UNESCO believes that, apart from their traditional functions, museums can do a great deal to improve international understanding. On the suggestion of the UNESCO several progressive museums have organized didactic exhibitions aimed at the easing of international tensions and the removal of prejudices. One such exhibition was organized by the Natural History Museum of Vienna in 1951 to illustrate the theme " Mankind, a Single Family ". The International Council of Museums with the help of UNESCO has been recently holding several conferences on education through museums, and UNESCO experts are at the moment helping South America and Greece to organize educational museums. A small pamphlet on " Museums and Young People " published by the International Council of Museums will be of special interest to educationists of this country. It is clear from what I have said above, that the question of the educational use of museums is no longer a matter of concern to a few isolated people, but is one of very wide international interest.

Turning now to conditions in India, one notes with regret that very little has been done to exploit the educational possibilities of museums. It is no doubt true that direct educational work, i.e., taking over the work of the class room, is not part of the work of a museum, its primary task being the collection and preservation of the cultural wealth of the country; but a live museum, while performing its primary tasks can usefully engage itself in putting its collections to the best use for the largest number. Our museums have been concentrating on the conservational aspect of their work almost to the exclusion of several

others. The new ideal, however, is to make museums "bright and cheerful instruction centres of the community". The appeal of modern museums generally is to the man in the street, not merely to the upper classes, and their aim is popular education in the broadest sense of the term, stimulation of intelligent curiosity, and the democratisation of knowledge of the various sciences and arts which in pre-democratic days were the prerogative of the *elite*. All these new ideals have been embodied in the Deutsches Museum in Munich, which is one of the marvels of the museum world of to-day. State-assisted visits to this Museum have become part of the educational system of Germany. Between the best of Indian museums on the one hand and the Deutsches Museum on the other hand, there is a vast gulf, but the time is ripe for inaugurating work in India in the right direction.

Some years ago, in a broadcast talk addressed to schools, I had made some suggestions to teachers and students interested in starting school museums. What I said then still seems to be useful, and so the talk is reproduced here:

"How shall we set about to organize a museum for our school? Can you send us a list of books that would help us?" I am asked these questions very often by friends from schools. If I tell them that books are not of much use, they might think I am withholding information. Of course there is no dearth of books telling you how to collect minerals, animals, plants, objects of art, etc., how to preserve, arrange, label and exhibit them. You may know all about these things, and yet no school museum would result from it, if you don't have an immense enthusiasm for knowledge, and an equal degree of intelligent curiosity about the processes of nature. Museums are not ends in themselves. Their purpose is "to raise the general level of refinement by giving pleasure and imparting knowledge". If the boys and teachers of a school are full of scientific curiosity and are prepared to overcome difficulties to satisfy it, they have then laid the foundation stone of their museum.

The educational value of museums, in the building of which the chief contributions are those made by school boys and their teachers, has been recognized by every one. In the United States of America, there are special museums for the exclusive use of children. Several of the larger

museums have children's sections. In India museums are very few in number, and schools have to depend more or less on their own efforts. Teachers as a rule know what their students are interested in, and these interests would be the basis on which their museums grow. Boys and girls have more interest in things around them and they are more anxious than older people to know what things are. I know a village boy who was greatly excited over the first bit of coal that he got the chance to see. I am also reminded of a friend who is now an authority on the subject of birds, but his interest in the subject began when as a scout he used to watch birds. Interesting facts about bird migration whetted his appetite for more knowledge. Can any boy help wondering when he gets to know that some of our birds come here from far off Siberia, Scandinavia and Iceland?

A scrap of information about one thing here, another scrap about something else there, are not the sort of knowledge that any one would care to have. A few odd curiosities spread on a dusty table would not make a museum. The collection in any museum should be arranged on a definite plan and should tell a connected story.

An increasing number of schools now-a-days have museums primarily to help the teachers in making their lessons more practical and interesting. Geography, botany and other field sciences are most effectively taught with the help of museum specimens. A modelled relief of your taluk or district is a hundred times more helpful than a flat map. Every example of minerals that the geography lessons deal with can be got by the joint efforts of the pupils and teachers. Bits of low grade iron ores are kicked about by you every day. One of you may have a relative working in the Nellore District who won't refuse you a present of a few bits of mica mined in that district, or you might come across it if you watch when a well is being dug in your own area. Boys can then easily study the different kinds of layers that make the earth on which their school stands. Samples of the different layers can be kept in the school museum for future reference.

A good collection of plants is also essential, but it is somewhat difficult to make you realise why it is so. Now let me ask you a frank question: How many of you—leaving out those belonging to the planting areas—have any idea of the nature, size and habits of the tea plant from

which your tea is got? Of course, your tea tastes equally well even if you don't know these, but knowledge is better than no knowledge. I am tempted again to give another illustration. Pepper, as you all know, is of great importance in the kitchen and also of great historical importance because European Companies were attracted to India by its pepper and spices. I showed a five inch long bunch of green pepper berries to half a dozen city dwellers, the first six to meet me that day, but not one of them could tell me that it was pepper. But these were elderly people, and if your boys are not to be like them, encourage the museum idea and help one another to see specimens of these essential agricultural products in your school museum.

There is the question of the school garden. Why should it be confined to merely ornamental plants? It can be made to help you in learning practical botany more thoroughly than in the class room. There are some schools with good botanical gardens, but their number should be greater. If the headmaster would spend a small amount on a cement tank, you can have a fresh water aquarium in your garden to watch how animals live in water.

I would recommend very strongly the maintenance of a nature diary by every boy and girl. In a good note book, make a record of what you see about your own house and school. Several English school boys and girls do it. When do your trees and shrubs put forth flowers? How long does each of them take to produce ripe fruits? When and how often do they shed their leaves? What kind of birds, butterflies and beetles appear in your compound? What plants die out and in what order during the beginning of the dry season? How many varieties of spiders can you see, on the ground or among shrubs? There are hundreds of such things that you can enter in your nature diaries, of which you will be proud when you grow up. In the course of this work you will develop your powers of observation and description. And you will come across several things which would interest your friends and would be worth exhibiting in your school museum.

Animals and plants are best studied in nature, but preserved specimens are also necessary, for the simple reason that you cannot safely examine the teeth or scales of a snake or the sting of a scorpion when these animals are alive. Similarly seeds, flowers and fruits may not be

available for your class when you want them badly. These ought therefore to be kept in stock. A ten per cent solution of formalin is a good general preservative.

When you have decided to do some of the things I have mentioned, the beginnings of a museum are also made. Then it is a question of properly housing and developing the collections. A good well-lighted room should be selected for the museum, if possible not right under the headmaster's nose, for children cannot be expected to be absolutely quiet, and a good school museum would sooner or later develop into a juvenile science club. It is absolutely essential also that from the very beginning the museum should be placed under the care of one of the teachers. If the scout master happens to be familiar with a few of the field sciences, he would make an excellent museum curator. To the scouter's equipment, he would then have to add a collecting box containing one or two small bottles of spirit, a killing bottle of cyanide and a few tubes and corks for the specimens collected during excursions. Schools that have sufficient funds would go in for a few glass-fronted almirahs to keep the exhibits, but shelves fitted along the wall would be enough for most exhibits. Special areas of the shelf accommodation are to be allotted to the various subjects. In one school museum, I have seen an attractive display of wood specimens, blocks of wood cut and polished in the shape of library volumes, and the name and use of the wood painted neatly at the back. Every museum specimen should be labelled. The best labels are either printed or neatly written in Indian ink. Typed labels are not good, as they fade rapidly.

Children are always fond of living things. For this reason no school museum should be without a small vivarium and an aquarium. A vivarium is a high sounding name for a glass-sided box, with small holes above, for keeping live animals. Small animals such as caterpillars, snails, etc., are kept and fed in these glass boxes and their peculiarities can be observed by the children. A boy or girl who observes the emergence of a butterfly from a cocoon gets a glimpse of nature's mysterious ways which would never be forgotten. The social organization of a termite hill can equally well be studied by classes of boys without much trouble and the king, queen, soldier and worker termites exhibited in the museum. When I speak of a school aquarium, you might think it is going to be a very expensive matter. Not at all. A couple of glass jars—shallow

ones are to be preferred—or, if you cannot afford them, a kerosene tin cut into two and one of the sides replaced with glass and made water-tight would serve the purpose equally well. Water beetles, small fishes, snails, etc., can be put into these tanks, and a few water weeds would help to keep the water aerated. Aeration can be effected by blowing into the water or changing the water a few times a day. Immediately after the monsoon frog spawns can be collected and put into the tank, and the children can watch the metamorphosis of the fish-like tadpole into the tailless frog. Some forms of spiders can be kept alive in bottles and their habits can be watched, but these creatures are cannibals who kill and eat their relatives and neighbours. The methods of breathing in fishes and frogs can be compared in the school aquarium. The life history of the mosquito is equally well studied by rearing the larvae in the aquarium. The methods of destroying the larvae can also be demonstrated in a control tank. The public health authorities would be thankful to the schools for spreading the knowledge about malaria control.

In schools on the sea-coast where sea water is available a number of marine animals, medusae, Portuguest-man-of-war, sea-slugs, etc., can be exhibited for short periods. Shells can be collected and exhibited and incidentally they add beauty to your museum shelves.

To make history lessons more interesting through the museum is more difficult. Only the bigger museums can do anything substantial in this direction. One school in the city of Madras has in its museum models of fortresses of the various epochs. This can be supplemented by photographic enlargements of historical monuments. One thing that every school can attempt to do is to have plaster casts of coins of the various important dynasties of India with the help of the provincial museums that have the originals. The Greek, Kushan, Gupta and other emperors become more real to the students if they can actually handle the coins issued by them or at least their facsimilies. Even as objects of art, Roman, Greek, Gupta and some of the Mughal coins have rare attractiveness. Modern coins and stamps will go together and would certainly be of interest

GOVERNMENT MUSEUM, MADRAS, A. AIYAPPAN,
2nd August, 1958. *Superintendent.*

HANDBOOK OF MUSEUM TECHNIQUE.

SECTION I.

Preparation of Zoological Museum Material.

By S. T. SATYAMURTI, M.A., D.SC., F.Z.S.
(Superintendent, Government Museum, Madras.)

Introduction.—As the setting up of a zoological museum, even on a small scale, requires a sound knowledge of the various processes involved in the proper preservation and display of animals, we have briefly outlined below the usual methods of collecting and preserving specimens of the main groups of invertebrate and vertebrate animals, the sources from which these specimens may be obtained and other techniques of Museum work such as preservation of eggs, preparation of skulls and skeletons, accessories such as foliage, artificial rock and ground work for habitat groups, enlarged models of small and inconspicuous animals and various methods of mounting and displaying the specimens for museum purposes. It should be clearly understood, however, that intensive practical training in museum work is always necessary if one is to acquire sufficient proficiency in these methods. Unfortunately, it is not possible to describe in detail in this limited space all the various techniques connected with museum preparation. Taxidermy and other museum methods of preservation and mounting are highly technical jobs requiring considerable skill and experience and it is therefore essential for everyone interested in this work to maintain contacts with the authorities of the larger public museums for information, training and guidance in these methods. However, it is hoped that the following information, supplemented by directions contained in the various books listed in the bibliography appended at the end of this handbook, might prove helpful in acquiring a knowledge of the fundamentals of museum technique.

Protozoa (or one-celled animals).—These are the lowest members of the animal kingdom and are so small that most of them can be seen only with the aid of a microscope, and are hence difficult to be dealt with as museum objects. The majority of these animals require expert technique for their proper preservation. But marine forms, such as Foraminifera and Radiolaria, which build hard chalky shells are easily collected and preserved. Living specimens of these groups may be collected from corallines and sea-weeds either by picking them off under a lens or by the use of a horsehair sieve with a bolting cloth fastened beneath it. The sieve should be immersed in sea-water and handfuls of sea-weeds, etc., shaken over it. The bolting cloth collects the animals

that pass through the sieve. Large areas of the bed of the ocean are covered by what is known as Globigerina Ooze, which consist almost entirely of the chalky shells of dead Foraminifera; sand or mud dredged from such areas may be dried and sifted and the finer siftings are then put into a bowl of water and stirred. The more delicate shells generally float on the surface and may be skimmed off. The heavier shells sink, and may be dried after the water has been drained away. The animals may be placed first in weak (50 per cent) alcohol and then in 70–90 per cent alcohol, or they may be placed directly in a neutralised 5 per cent solution of formalin.

For museum purposes, enlarged models of protozoans may be prepared to scale from a study of the actual specimens under the microscope. A plasticine model is first prepared and a plaster mould of this model is taken. A beeswax or plaster cast is prepared from this mould and the cast painted in natural colours and mounted suitably in a glass-topped box. The details of the process of moulding and casting are much the same as for reptiles, fishes and other subjects described later on (pp. 29 and 25). The actual specimens of protozoans can only be mounted as microscopic preparations on glass slides.

Porifera (Sponges).—Sponges are sedentary animals found living in the sea between tide marks and at all depths and also in fresh water. They are generally attached to stones, rocks, and sea-weeds and may form solid branching or encrusting masses. Freshwater sponges are usually bright green and may be mistaken for aquatic vegetation. Shallow water marine sponges are often found in sheltered places under rocks or in crevices of dead coral. The best preservation for sponges is strong (70–90 per cent) alcohol, which should be changed after 24 hours. They may also be preserved dry by drying them thoroughly in the sun after washing with fresh water. After drying they may be immersed in shellac varnish and re-dried, to give them a protective coating The dried specimens may be mounted on wooden pedestals or in glass-topped boxes.

Corals.—These are the hard skeletal parts of lowly organized invertebrate animals living in the tropical seas in shallow water. When taken fresh from the sea, they are slimy and variously coloured as they contain the fleshy living parts of the animals. Corals are generally preserved as dry specimens, but a small portion of the colony should always be preserved in alcohol for examination of the soft parts. For dry preservation, the corals are soaked in tubs of fresh water for a few days. They are then washed thoroughly in several changes of fresh water, splashed with handfuls of clean water, brushed with a coarse brush and dried in the sun. They are thus bleached perfectly white, and make good museum exhibits when mounted on wooden pedestals painted with black enamel paint or in glass-fronted boxes with a black interior.

Hydroids, Sea-anemones and Jelly fishes.— The shallow water kinds of marine hydroids (plant-like, branching, colonial animals) and sea-anemones may be found in pools exposed by the receding tide. Large stones and boulders immersed under water such as in the Madras Harbour or under the long railway bridge over the Pamban pass are particularly rich in hydroids, some of which possess powerful stinging cells. Sea-anemones may be generally found half buried in soft sand or mud on large mud flats exposed at low tide. Such animals should be carefully dug out of the sand with the aid of a shovel. Jellyfishes are soft-bodied pelagic animals (i.e., floating on the surface of the sea) and are obtained by means of a townet, preferably at night, when they are more abundant at the surface. Occasionally, jelly fishes and other pelagic coelenterates such as the Portuguese man-of-war are found washed ashore on the sandy beaches.

When collected alive from the sea, hydroids, sea-anemones and jellyfishes should be placed in basins of clean sea-water and allowed to expand, undisturbed. It is advisable to keep them covered while expanding, in order to prevent excessive light. When fully expanded, they should be narcotised or anaesthetised (i.e., rendered insensible to touch) by gradual poisoning with formalin. This should be done by adding at first only a few drops of commercial formalin to the water containing the animals and then, at intervals of about fifteen minutes, stirring in a little more, until about one-tenth of the total volume consists of formalin. An alternative method of anaesthetising the animals is to add handfuls of magnesium sulphate crystals to the sea-water contained in the basin. When they are insensitive to touch, they may be thoroughly washed in fresh water and transferred to 4 per cent formalin in which they are best preserved.

Planarians (Flat worms).—Planarians are free-living flat worms found under stones and among plants growing in fresh water and on dead coral rock and stones in rock pools and exposed reefs on the sea-shore. They may be collected by picking them up with the fingers, or with a pair of forceps or a soft camel hair brush. Land planarians should be looked for in damp places, under decaying logs of wood or among mosses.

The animals should be placed in a dish of water (sea-water for marine forms), and as much as possible of the water poured off. When the animals are extending a thin glass plate such as a slide is placed over them and the preserving fluid should be suddenly injected over them with a pipette. This should consist of 3–5 per cent formalin or better still, of the following solution: Strong nitric acid 3 volumes; saturated corrosive sublimate solution 3 volumes, water 4 volumes. The worms should be left in this solution for a few minutes only, and the fixative washed out by several changes of water or 70 per cent alcohol. The best storing fluid is 70–90 per cent alcohol to which the specimens may be transferred directly.

Marine Bristle worms (Polychaeta).— Many of these worms may be found between tide marks on the sea-shore. Some of them burrow into crevices of coral rock and stone on reefs, while others burrow in mud and sand, and their "casts" may be observed on the surface. Those burrowing into rock may be extracted with a pair of forceps or a paint brush after breaking open the rock with hammer and chisel. Worms burrowing into mud or sand may be dug up with a shovel. Pieces of stones, corals or sponges brought up in a dredge may be left in basins of sea-water and the water allowed to get stale. After a few hours the worms will emerge from their hiding places and collect on the bottom and sides of the basin. The water should then be changed and the process repeated, when more batches of worms will appear as the water grows stale.

The worms should be placed in a dish or jar of sea-water and anaesthetised by the gradual addition of alcohol to the water containing the worms. The alcohol should never form more than a tenth part of the total volume. Another method is to add crystals of menthol to the sea-water. As soon as the worms cease to respond to stimulus, they may be straightened out in a flat dish and stiffened by pouring alcohol. After 12 to 24 hours they should be transferred to fresh 70–90 per cent alcohol, and the alcohol may be changed again after 24 hours. Finally, they may be stored permanently in this fluid. For ordinary purposes Perenyi's fluid (see Appendix B) is rather better as a fixative than alcohol. After anaesthetisation the worms may be placed directly in this fluid and transferred to 70–90 per cent alcohol after a few hours.

Earthworms (Oligochaeta).—Earthworms may be obtained by digging in the surface layers of the soil in moist places. Many of them emerge from their burrows after rain, when they may be easily collected.

The worms are placed in a dish with sufficient water to cover them and should be anaesthetised by gradual addition of alcohol in small amounts at intervals of a few minutes, or by placing a few crystals of menthol or magnesium sulphate in the water. When they are thoroughly limp, they are transferred to 10 per cent formalin in a flat dish to keep them straight until they stiffen. They are left in formalin overnight and then transferred to 70–90 per cent alcohol.

Leeches (Hirudinea).—Leeches may be found among weeds, mud and stones from ponds or lakes, and shrubs and low vegetation in swamps and tropical forests, but they are more frequently found attached to some animal. When they are very firmly attached, they may be induced to loosen their hold by placing salt on them.

As leeches are liable to extreme contraction, great care should be taken while preserving them. They should be placed in a dish with a little water and carefully anaesthetised by the addition of

small quantities of alcohol or a few crystals of magnesium sulphate. When they cease to respond to touch, the worms should be straightened out and laid in a flat dish. Alcohol (70 per cent) or formalin (3–5 per cent) may then be poured over them. Small flattened forms may be compressed between two plates of glass, bound-together with rubber bands and immersed in the fixing fluid. After 12–24 hours they should be transferred to fresh 70–90 per cent alcohol or 3–5 per cent formalin in which they may be permanently stored.

Molluscs (Snails, Clams and other shell-bearing animals).—Molluscs occur on the land, in freshwater and in the sea. On land only snails and slugs are found. They should be looked for in crevices in rocks, under stones, dead bark, logs, on trees, etc. Freshwater molluscs such as pond snails and freshwater mussels may be found in tanks, ponds and lakes, particularly those having plenty of water weeds growing in chalky water. These molluscs may be collected with a coarse net or wire sieve fixed at the end of a long pole. Marine molluscs may be found between tide marks on the sea-shore; some forms burrow deeply into rocks, which must be split with a hammer and chisel. Many molluscs lie buried in the mud and sand, and may be obtained by digging and sifting. Molluscs living in deeper waters may be collected by dredging. Empty shells are frequently found washed up on the beach, but these are usually in a poor condition.

Wet Preservation of Molluscs.—Wherever possible, two series of specimens should be preserved one of dried shells and one of the entire animals in fluid for the study of the soft parts. For the soft parts the best preservative is alcohol; 5 per cent formalin may also be used, but this should be neutralised by the addition of 5 grammes of borax to every litre of the full strength solution, as otherwise it has an injurious action on the shells. Marine molluscs should be narcotised with magnesium sulphate crystals in an expanded condition and then transferred to successive changes of alcohol of increasing strength (30 per cent, 50 per cent and 70 per cent) to avoid shrinkage and violent contraction. Finally they may be preserved in 70–90 per cent alcohol. Land and freshwater molluscs may be narcotised by asphyxiating them in a stoppered bottle quite full of water. In 24 hours they would be anaesthetised and fully extended, and may be preserved after their mucus has been removed with cotton wool. If time is short, land and freshwater snails and slugs may be killed by plunging them into boiling water at the moment when they are fully extended. This may be done by allowing them to crawl to the end of a twig and then suddenly immersing the twig. The snails may then be washed and preserved in 70–90 per cent alcohol.

Dry Preservation of Shells.— As shells have a membrane which should not be destroyed, they should be carefully cleaned with a soft brush. Land and freshwater molluscs should be killed

in boiling water, after which the body may be extracted with a pin or a pair of forceps. The shells should be dried in the air, but not in direct sunlight. Marine shells should be washed with fresh-water and the specimens buried in sand (not saw dust) and left in the shade until the soft parts dry up. As hot water destroys the lustre of marine shells, they should not be washed in it. Many snails possess a calcareous or horny plate or lid covering the aperture of the shell, called the operculum. This, after removal of the fleshy contents of the shell, should be carefully preserved by pasting it on to a plug of cotton wool inserted into the shell. Bivalve shells (clams, cockles, mussels, etc.) open the shells when they die, and after the soft parts have been extracted, the valves should be closed tightly and tied together with thin white thread. A coating of vaseline or a thin wash of clear picture varnish may be finally given over the shells to preserve their colour. The shells may be stored in boxes lined with cotton wool, or may be mounted individually on painted glass plates with pellets of plasticine or celluloid cement, if required for exhibition purposes.

Echinoderms (Star-fishes, Sea-urchins, Sea-cucumbers).—Starfishes, sea-urchins and sea-cucumbers are exclusively marine animals and may be found between tide marks, lying exposed in pools or buried in sand. Many seek shelter underneath rocks, stones and sea-weed, etc. A favourite situation is the base of dead coral and stones on the reefs. The burrowing forms may be obtained by digging near low watermark. Those frequenting deeper waters must be collected by dredging.

Except for the sea-cucumbers, nearly all Echinoderms can be preserved dry, but as dry specimens tend to become extremely brittle in course of time it is safer to store at least a part of the collection in alcohol. To preserve starfishes dry, they should be taken alive from the sea-water and laid on a board, until collapsed. Then they are immersed, while alive, in 10 per cent formalin solution until they swell up to natural shape and harden. The starfishes are now removed from the formalin and drained well so that the solution returns to its container. They are then dried on a board and turned occasionally so that drying may be uniform. The dried starfish may be mothproofed by being briefly immersed in borax solution and then redried. The natural colours may then be replaced with oil paints and a coating of varnish may be given finally. Sea-urchins should have two small holes pierced in their shells not at the centres, of the upper and lower surfaces and the sea-water should be poured out. They should be then placed in fresh water for half an hour and transferred to 5 per cent formalin for a few hours and then allowed to dry. A still better method is to use a 1 in 1,000 solution of corrosive sublimate instead of formalin. In this the specimens should be left for about twelve hours before drying. The shells of sea-urchins need not be punctured if this method is used. If no preservatives are available the shells

of sea-urchins may be dried after cutting a hole in the lower surface and removing the soft parts. For the wet preservation of Echinoderms, 70–90 per cent alcohol is preferable to formalin especially in the case of sea-cucumbers in which the calcareous spicules in the skin are destroyed by formalin. Starfishes and sea-urchins may be killed and preserved by placing them directly in 70–90 per cent alcohol. Sea-cucumbers should be narcotised with magnesium sulphate or menthol crystals. When thoroughly narcotised, the animals should be gripped with forceps behind the tentacles to prevent their retraction and the tentacles immersed in 5 per cent formalin or glacial acetic acid. 70–90 per cent alcohol should at once be injected into the body cavity through the anus and the specimens then stored in alcohol.

Arachnids and Myriapods.—Spiders, scorpions, ticks and mites are grouped under the class Arachnida and centipedes and millipedes constitute another distinct class, the Myriapoda. The general methods of collecting Arachnida and Myriapoda are the same as those employed for insects. They may be collected by sweeping vegetation with a strong net or beating bushes over an inverted umbrella. The majority of Arachnids, however, hide themselves from light, and should be sought in dark places, under logs and stones, in heaps of vegetable matter, under the loose bark of trees, in crevices of rocks and other similar situations. The larger and stronger forms may be picked up with forceps. Scorpions and some of the larger spiders are poisonous and should be handled with care. Smaller specimens may be induced to drop into small glass tubes with the aid of a camel-hair brush. It is advisable to carry a number of glass tubes, most of them three-fourths full of 70–90 per cent alcohol into which the specimens can be transferred after capturing them in empty tubes. Water mites may be collected by sweeping water weeds with a hand-net. They should also be searched for by washing bunches of weeds and by examining submerged stones covered with moss and algae. Many mites and ticks are parasitic on other animals, chiefly vertebrates such as reptiles, birds and mammals. Ticks are generally large enough to be seen with the naked eye, and can be picked off with a pair of forceps. If the tick is firmly attached, the surrounding skin should be dabbed with oil or benzene to loosen them and may then be gently pulled off, taking care to see that it does not leave its mouth parts buried in the skin of the host. Mites are very small and not easily seen among the feathers and hairs at the base of which they live. They may be collected by combing the fur with a fine comb and picking them off under a lens. For capturing Myriapods (millipedes and centipedes) the following method may be found helpful : A shallow pit is dug in the ground. The pit is lined with hay or grass to retain moisture, and baited with bits of potato, beans or other food material. A tile or board is laid over the bait and the pit may, if desired, be filled in with soil. In dry weather the pit should be frequently watered.

Preserving.—All Arachnids and Myriapods may be killed and preserved in 70–90 per cent alcohol, which should be changed after 12-24 hours. Larger forms such as scorpions and large spiders may be killed with a few drops of Chloroform and then preserved in 70–90 per cent alcohol. For mites and ticks a special preservative known as Oudeman's solution (see Appendix B) and for water mites Viet's mixture (see Appendix B) is recommended as a preservative. In order to display to the best advantage the appendages of spiders, scorpions and ticks, they may be spread out and the specimen mounted in this position on a glass plate or a sheet of mica and secured in position with celluloid cement prepared by dissolving celluloid shavings in amyl acetate. The glass plate with the mounted specimen may then be immersed in a jar of alcohol. Dried specimens of spiders and scorpions tend to become brittle.

Insects.—Insects are collected in various ways. Bees, wasps, butterflies and dragonflies may be caught on the wing with a butterfly net. Insects should also be looked for on flowers, under

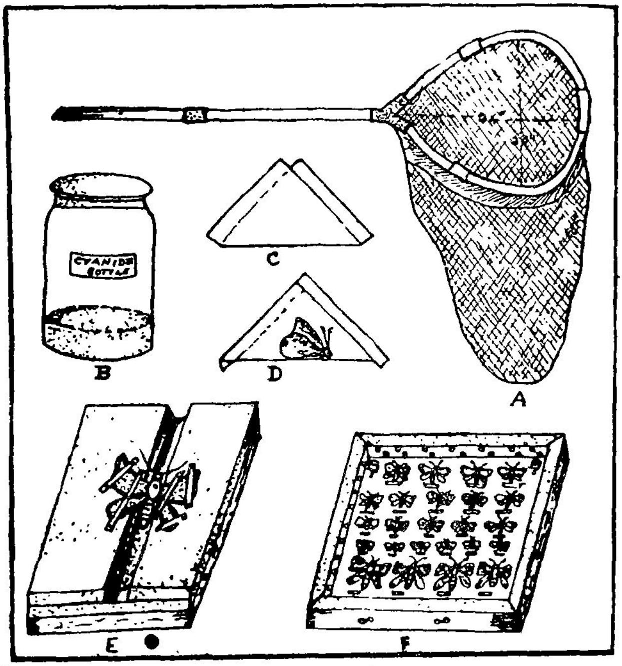


FIG. 1. EQUIPMENT FOR INSECT COLLECTING.
A. BUTTERFLY NET;
B. CYANIDE KILLING BOTTLE;
C. RECTANGULAR PIECE OF PAPER FOLDED TO MAKE TRIANGULAR ENVELOPE;
D. COMPLETED PAPER ENVELOPE WITH THE EDGES FOLDED IN SHOWING THE POSITION OF THE BUTTERFLY INSIDE;
E. SETTING BOARD WITH THE BUTTERFLY SET ON IT;
F. A SINGLE GLASS-TOPPED DRAWER FROM A BUTTERFLY CABINET.

bark of trees, in rotten wood, in decaying animal and vegetable matter, under stones, under fallen leaves where there is moisture, at the roots of grasses and trees and in ponds and streams. Ground beetles may be caught with a pair of forceps from under stones and decaying logs of wood. They may also be collected by placing a piece of meat in a pickle bottle, and burying it so that the mouth is just on a level with the ground. Moths, some beetles and other nocturnal insects are obtained by painting patches of sugar on the trunks of trees, and looking for them with a lantern after dark. Moths may also be caught by hanging up a sheet of white cloth with a lantern behind it. They are attracted by light, and may be picked off with glass-bottomed tin boxes as they settle on the sheet. Some beetles and other carnivorous insects may be obtained by hanging up skins of animals, or the carcases of small mammals or birds.

Most insects are easily killed by dropping them directly into the cyanide killing bottle. This should be a wide-mouthed bottle with a tight-fitting ground glass stopper. At the bottom of this bottle a layer of lumps of potassium cyanide packed with compressed masses of tissue paper is made up to a height of about one inch and over this are placed two or three circular pieces of blotting paper cut to the size of the circumference of the bottle, to absorb moisture. As potassium cyanide is extremely poisonous, the killing bottle should be handled with care and should always be kept under lock and key when not in use. Insects die in a few seconds when dropped into this bottle, but care should be taken to see that the sides of the bottle and the surface of the cyanide layer are not wet, as the more delicate insects are apt to stick to the surface and get spoiled. While collecting beetles and bugs, this may be prevented by filling up the empty space in the bottle above the cyanide layer with crumpled pieces of blotting paper, or tissue paper among which the insects may bury themselves. This also prevents them from rolling about and injuring each other. The specimens should never be left in the killing bottle longer than necessary, as cyanide changes the colour of some insects, green becoming yellow and yellow turning into red. An alternative method of preparing a killing bottle is to place a wad of cotton wool soaked in chloroform at the bottom of a wide-mouthed bottle with an air-tight lid and making a false bottom with a circular piece of wire gauze over the cotton wool. The insects are dropped on the wire gauze and the lid tightly closed when they die in a few seconds. Beetles, bugs, grasshoppers and other non-hairy insects may be killed by throwing them into boiling water, but they should be taken out as quickly as possible and placed on sheets of blotting paper to drain off the water. Butterflies may be killed by pinching the thorax laterally while the wings are in an upright position.

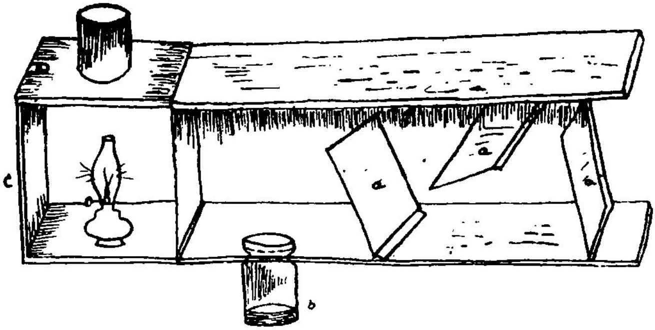


FIG. 2. LIGHT TRAP FOR COLLECTING INSECTS.
a. GLASS BAFFLES; b. INSECT KILLING BOTTLE;
c. LIGHT CHAMBER; d. TOP PANEL OF LIGHT CHAMBER WITH OPENING.

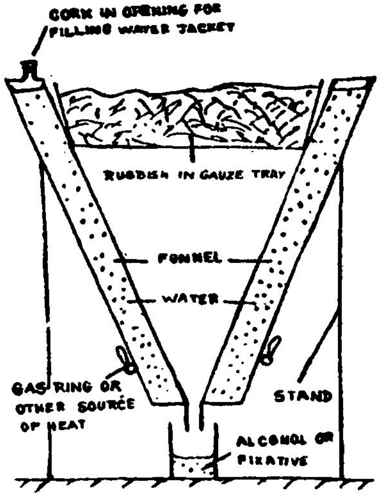


FIG. 3. BERLESE FUNNEL, DIAGRAMMATIC SECTION.

When the insects have been collected and killed by one or the other of the various methods described above, they may be pinned immediately if time permits, or they may be temporarily packed in boxes for pinning at a later date. In packing insects, cotton wool should *never* be allowed to come in contact with insects. Beetles and bugs may be wrapped in pieces of tissue paper and the two ends of the paper twisted in opposite directions in much the same way as sweets and toffees are wrapped. Butterflies and moths should be put into triangular paper envelopes with their wings folded together over their backs. These envelopes may be made thus: an oblong piece of soft white paper is taken and folded diagonally in such a way as to form a triangle, and the overlapping edges are then folded in opposite directions so as to make a more or less closed triangular envelope. The envelopes with the insects inside may then be packed in tins or cardboard boxes into which some naphthalene powder is sprinkled. When insects that have been packed thus have to be set and pinned, they should first be relaxed by placing them in a relaxing bottle for a few hours, before pinning them, to render them sufficiently flexible. The relaxing bottle is prepared thus: A layer of moist sand about 1½ inches thick is spread at the bottom of a wide-mouthed bottle, and two circular pieces of blotting paper are laid over the sand. The insects to be relaxed are dropped into this bottle and the lid closed. To prevent moulds forming inside the bottle, a few drops of lysol solution may be poured into the bottle. After a few hours, when the wings and legs of the insects are soft and pliant, they are well relaxed and ready for pinning.

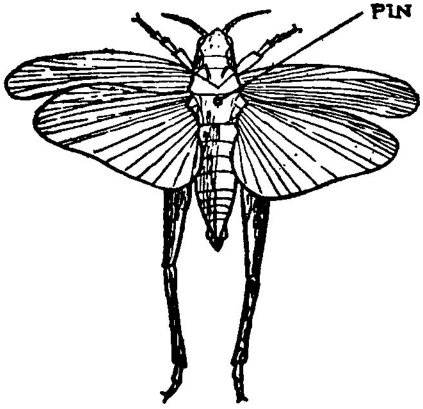


FIG. 4. METHODS OF PINNING VARIOUS INSECTS: GRASSHOPPER WITH WINGS SPREAD OUT.

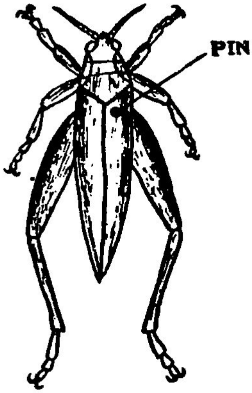


FIG. 5. METHODS OF PINNING VARIOUS INSECTS: GRASSHOPPER WITH WINGS CLOSED.

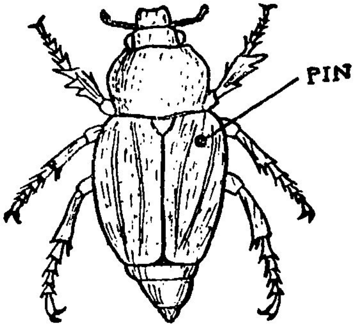


FIG. 6. METHODS OF PINNING VARIOUS INSECTS: BEETLE.

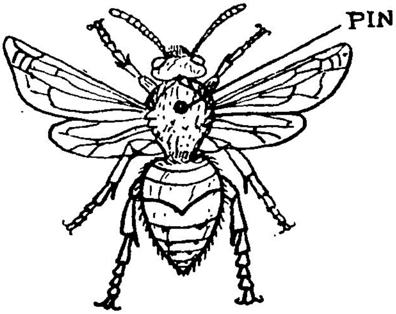


FIG. 7. METHODS OF PINNING VARIOUS INSECTS: BEE.

The method of pinning varies with different types of insects Butterflies are placed in grooved cork setting boards in such a way that the abdomen and thorax lie in the groove and the wings are

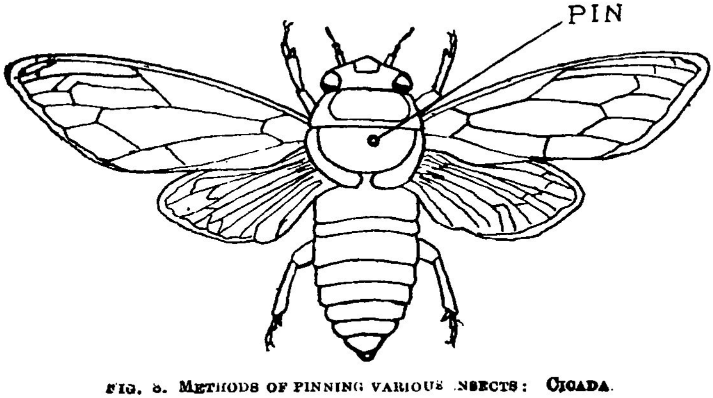


FIG. 8. METHODS OF PINNING VARIOUS INSECTS: CICADA.

spread out flat over the cork sheets on either side of the groove. A single long pin is passed through the thorax of the butterfly and stuck into the bottom of the groove. The wings are then secured in position over the cork sheets by means of narrow strips of paper passed criss-cross over the wings. The extremities of each of these stips of paper are pinned down to the cork sheets with fine entomological pins. The setting board with insects pinned on them are placed in a dry box and left for 10 to 14 days during which time they dry and stiffen in the desired position. At the end of this period, all the pins, except that passing through the body of the insect, are removed. The butterflies may then be transferred to the cabinet or storage box by means of the single pin passing through its body.

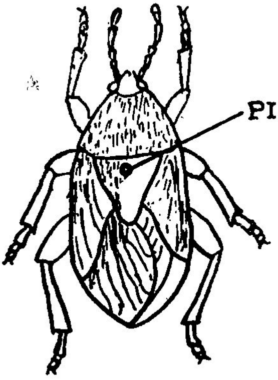


Fig. 9. Methods of pinning various insects: Hemipteran Bug with large scutellum.

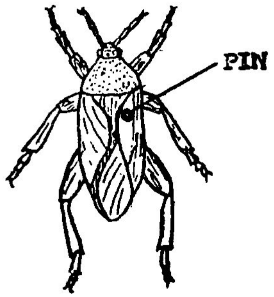


Fig. 10. Methods of pinning various insects: Hemipteran Bug with small scutellum.

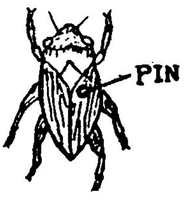


Fig. 11. Methods of pinning various insects: Homopteran Bug with wings closed.

Fig. 12. Methods of pinning various insects; Homopteran Bug with wings spread out.

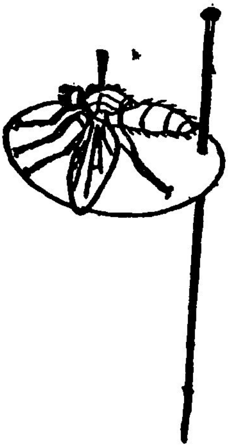


FIG. 13. PINNING SMALL INSECTS USING DISCS.

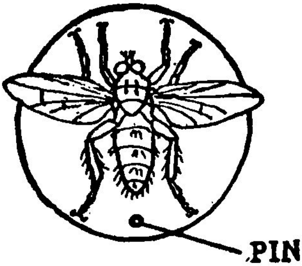


FIG. 14. PINNING SMALL INSECTS USING DISCS.

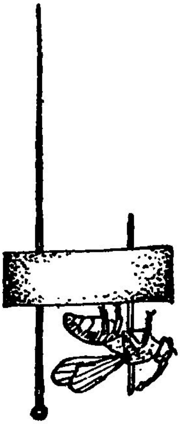


FIG. 15. STAGING ON PITH.

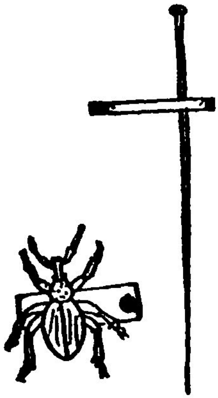


FIG. 16. CARDING.

Moths are preserved in much the same way, but in the case of large and bulky specimens of moths it is necessary to slit open the underside of the abdomen, remove the viscera, stuff the abdominal cavity with some cotton wool soaked in 4 per cent formalin and the abdominal wall is then flapped back into position. The moths are then set on broad-grooved setting boards as usual.

Beetles and bugs which normally have their wings closed over their backs and pinned over plain cork boards or pith blocks. In the case of beetles the central pin passes through the right *elytron* (or the hard upper wing cover), and in bugs it is passed through the little triangular plate behind the thorax, known as the *scutellum*. The legs are spread out and pinned in the desired position by pairs of pins passed criss-cross over them. The pith blocks or cork sheets with the pinned insects may be put away to dry in a box for about a week or two. The insects, when dried and set in this position, may be released from the setting boards by removing the pins from the legs and lifting them off by the single pin passing through the body. Bees, wasps and dragonflies may be pinned with their wings spread out like butterflies on grooved cork setting boards with the central pin passing through the middle of the thorax. Locusts, grasshoppers and crickets should be pinned in the middle between the bases of the wings, if the wings are spread out. But they may also be pinned without the wings being spread, in which case the pin should pass through the right wing. Cicadas and other large Homopteran bugs may be pinned through the large middle segment of the thorax (*the mesothorax*). Small insects like weevils and bed bugs may be mounted by being gummed on small strips of cardboard near one end of which is passed a long pin by which the carded specimen may be pinned inside the storage box. Flies and mosquitos (*Diptera*) should be pinned with fine entomological pins on small blocks of pith or circular cardboard discs near the margin of which a long pin may be passed for purposes of handling and storage. While making collections of insects, it is always important that a label mentioning the locality, date of capture, elevation and other details should accompany every specimen. This label is best carried under the specimen by the pin passing through the insect or the block of pith or card on which the insect is mounted, in the case of small or minute insects. The various methods of pinning insects are illustrated in the accompanying figures (see Figures 1 and 4–16). Wooden boxes with hinged lids provided with hooks are suitable for storing insects. Better still are insect cabinets with a number of uniform-sized cork-lined drawers with framed glass lids. The essentials for storing insects permanently are: (i) To keep out dust; (ii) to keep them dry; (iii) to keep them in the dark and (iv) to keep out pests. Storage boxes and cabinets will accomplish the first three of these conditions, but in order to keep out pests it is necessary to employ certain disinfecting agents. Powdered naphthalene may be placed in a narrow perforated chamber all round in

the drawers and boxes containing the insects. In addition to this a compact plug of cotton rolled round a long pin may be dipped in a strong solution of lysol and camphor or a mixture of chloroform, creosote and naphthalene (see Appendix B) and pinned in the four corners of the storage box or cabinet drawer as the case may be. For exhibition purposes insects may be mounted in cork-lined plywood boxes with glass tops bound with calico round the margins. Insects are, as a rule, preserved and stored dry as described above, but when they are required for dissection and anatomical investigation, they should be preserved in 70–90 per cent alcohol, or better still, in Pampel's fluid (see Appendix B) or 5 per cent solution of chloral hydrate. Insects which are to be preserved in these fluids will have to be first chloroformed and have thier body walls slit at some suitable point to assist the penetration of the fluid.

Preparation of Insect larvae.—Insect larvae (caterpillars, grubs, etc.) may be preserved in 70–90 per cent alcohol, but a better method of preserving caterpillars by inflation has long been used by entomologists. The larvae should first be killed in a cyanide killing bottle or in alcohol. Cyanide is generally considered the best for most larvae. The caterpillar is placed on piece of blotting paper, a pencil is rolled over the larva from the head to the tip of the body, thus protruding the tip of the alimentary canal. This is snipped off by a pair of scissors or a sharp knife, and then by rolling a pencil, as before, a number of times over the larva the contents of the body are squeezed out. One should be careful to do it rather slowly, at least with delicate larvae, so that the skin is not broken, for, if rubbed too long or too hard the pigment may be removed from the skin. A glass tube with its tip drawn out to a fine point is then inserted into the anal opening. The skin may be fastened on the slender point by a bit of thread or a drop of glue. If the glass tip fits rather tightly into the aperture, then the skin may be placed a moment on a wire gauze held over a spirit lamp flame and then withdrawn. A spring or clasp of steel may be so arranged as to hold the larva to the tube. The skin may now be inflated by blowing in through the glass tube. But a more effective way is to have a rubber tube on which is a large pneumatic bag and a smaller inflating bag at the end. By squeezing the inflating bag, the larger bag becomes inflated, and this makes a steady pressure upon the larval skin. This operation of inflating the larva should be performed over a small tin over as shown in the accompanying figure (see Figure 17). The glass tube with the attached larva (see Figure 18) is inserted through the hole " d ". If one expects to inflate many larvae, an apparatus of this sort will be found to be very useful. But for occasional use, a bottomless tin can supported by a wire gauze frame over a spirit lamp flame, is an effective substitute. The direct and inflated larval skin may then be touched up with natural colours and

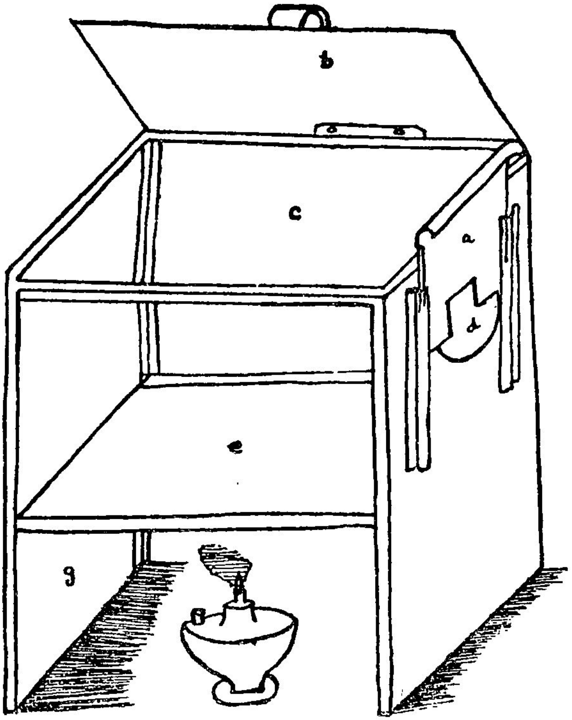


FIG. 17. APPARATUS FOR BLOWING INSECT LARVAE.
SIDE SHUTTER: b. LID; c. BACK PANEL; d. OPENING FOR INTRODUCING THE LARVA; e. BOTTOM PANEL; f. SPIRIT LAMP; g. STAND.

FIG. 18. HOLDER FOR THE LARVA.

stored in the insect cabinet, preferably along with the corresponding adult insects. The blown larvae may be secured in a loop of copper wire fixed to a small cube of cork which may be pinned in the cabinet or storage box or it may be mounted in a glass tube if required for exhibition purposes.

Crustacea (Crabs, Prawns, etc.).—Free swimming forms, whether marine or fresh water, may be collected with the aid of a net. Several kinds of crabs and shrimps are found between tide marks on sea-shores. They should be looked for in crevices of rocks, corals and wooden piles or among weeds. These may be collected with the aid of a long pair of forceps. Long wooden forceps are useful for handling the larger kinds as they are likely to inflict severe wounds with their enormous claws. Crabs cannot, however, nip the hands if held with the thumb and fingers at the sides of the carapace. Digging the sand just above low water mark on sandy beaches or estuarine mud flats will often yield a large collection of crustaceans which are burrowing in habit. Fishermen are often very helpful in obtaining specimens of those forms which inhabit deeper waters.

Hermit crabs inhabiting shells of molluscs may also be frequently collected between tide marks on coral reefs and shores where mangroves abound.

Preserving.—Small shrimps may be killed in 5 per cent formalin and transferred to 70–90 per cent alcohol, but, as a rule, the larger crustacea are best killed and preserved by dropping them directly into strong rectified spirit (96 per cent alcohol). The main difficulty with these animals is their habit of shedding their limbs when touched or immersed alive in spirit. This can be overcome to a certain extent by the following means : Most fresh water crabs are rapidly killed by exposure to the sun and marine forms, by drowning in fresh water. They should not be left too long in the latter, but should be transferred quickly to 70–90 per cent alcohol. The rigidity which often results from this method may be prevented by immersing in successive changes of weaker spirit before finally preserving in strong spirit. If a number of crabs are to be packed in the same jar, it is advisable to tie up each specimen in separate muslin bags so that the legs, if broken, may not get mixed up with those of other specimens. For display purposes, crabs are better preserved as dry specimens as they can be painted in natural colours in this condition. The abdominal flap is folded back and a slit made in the lower wall of the cephalothorax (in the body proper). Through this opening. all the flesh and muscles from inside the body and the bases of the legs are removed with a pair of forceps and mounted needles. The legs may be detached in this process in the case of the larger crabs, when each of the legs has to be cleaned of its fleshy contents individually and pasted back in position with celluloid cement (see Appendix B). The interior of the body is then thoroughly washed with strong formalin and stuffed with

cotton wool soaked in weak carbolic acid lotion or borax solution. The abdominal flap is then folded back into its natural position and pasted down with celluloid cement and wound up with the body with colourless thread. The legs may then be properly arranged and fixed in their correct positions on a board with pins passed over them criss-cross and allowed to dry. After a few days, when the specimen is completely dry, the pins and thread are removed and the original colours are replaced with oil paints and the surface lightly coated with paper varnish when the colours are dry.

Vertebrates—Fishes.—Collections of fishes may be generally made in three ways (1) specimens may be collected in their natural habitats by use of nets, traps lines and other fishing gear, (2) they may be obtained by the co-operation of the local fishermen or (3) they may be procured by means of frequent visits to the fish markets. The Department of Fisheries will be able to advise on matters connected with the use of suitable nets and traps for fishing. Fishing with rod and line may be indulged in as a sport, but *it is definitely not to be recommended for scientific collecting*, as comparatively few specimens of any value have been obtained by this method. Small rock pools left uncovered by the receding tide may be explored for fishes with advantage, as this type of habitat renders collecting comparatively easy. The clefts in rocks, sponges, large bunches of seaweed and masses of coral, sea-squirts, etc., which should be broken open and carefully examined, are all likely to yield interesting specimens of fishes. All fishes collected should be accompanied by labels giving the data and locality and, if possible, any information regarding sex, breeding habits and food of the fishes. For specimens preserved in fluid, parchment labels may be written with good waterproof Indian ink and tagged on to the fishes at the base of the caudal fin. If the colour of the fish is remarkable, the collector is recommended to make a coloured sketch, if possible, before preserving the specimen, or, at least, to make a note of the colours in life. It is advisable to maintain a notebook in which these coloured sketches and other field observations may be carefully recorded.

Fishes may be preserved either in fluid or as a dry, stuffed specimen, and for display purposes in museums it is also usual to make painted plaster or wax casts of the fishes.

Wet Preservation of Fishes.—For study purposes, it is best to preserve fishes in fluid. For the great majority of fishes, strong alcohol (70–90 per cent) is preferable to formalin, but, in the case of larvae and fragile oceanic fishes, a 4 per cent solution of formalin gives good results. The first essential of good preservation is to make certain that the preserving fluid reaches all the internal parts, more particularly the stomach and intestines. The easiest method of doing this is to inject 70 per cent alcohol or 5 per cent formalin into the alimentary canal through the mouth and vent, and also,

through a ventral incision, into the body cavity. If no syringe or pipette is available, several short slits (1 to 2 inches long, depending on the length of the specimen) may be made slightly to one side of the mid line of the belly, avoiding, as far as possible, damage to the scales. The specimen is then completely immersed in a relatively weak solution of the preservative fluid (50 per cent alcohol or 2 to 3 per cent formalin, as the case may be) for a period of one to three days. The specimen is then transferred to a second stronger bath (65 per cent alcohol or 4 to 5 per cent formalin). In this, it may be allowed to remain for a period of a week or a fortnight. If the specimen is large it may require a few more changes of stronger solutions of the preservative fluid and finally, when fully preserved, the specimen may be permanently stored in strong 90 per cent alcohol or 5 per cent formalin, but, as mentioned earlier, alcohol is preferable to formalin, as the latter renders the specimens extremely brittle in course of time. In mounting fishes in specimen jars for display purposes, care should be taken to see that the fins are properly spread out and displayed to the best advantage. When out on a field trip, where it is necessary to pack a large number of specimens in the same container, it is advisable to wrap each specimen individually in pieces of clean, white, fine-meshed cloth, with its label placed inside the package. Where it is desired to transport a consignment of preserved fish, the specimens may be packed in tin containers lined with cottonwool, filled to the brim with 70 per cent alcohol and soldered so as to render it air-tight.

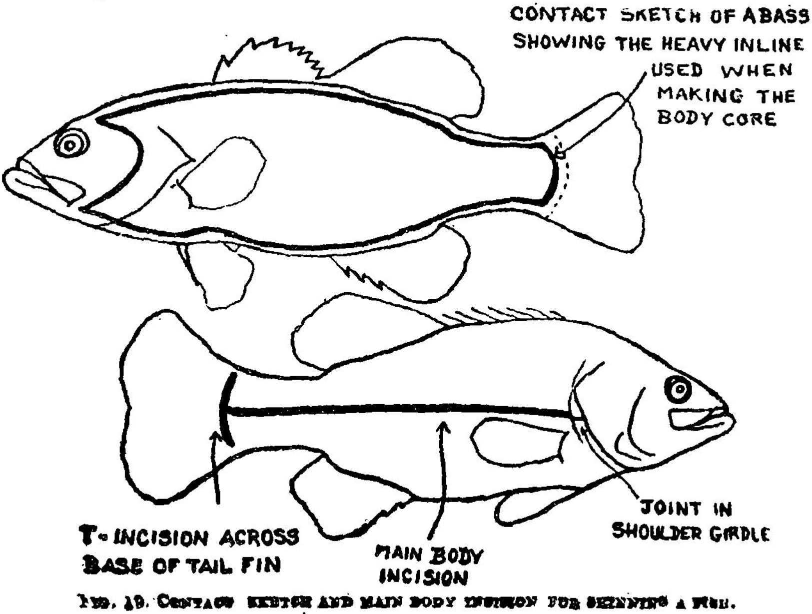


FIG. 19. CONTACT SKETCH AND MAIN BODY INCISION FOR SKINNING A FISH.

Preparing and Mounting a Fish as a Dry Specimen.—Generally, the hard-scaled kinds of fishes are easier to skin and prepare as dry specimens. The fish is laid on a sheet of brown paper and a contact outline of the body is traced on the paper. The specimen is then pasted all over with a sheet of tissue paper to prevent the scales from being shed while skinning. When the pasted paper has become dry and stiff, the fish is laid on its better side on a wet oil cloth on the work table. An incision is made with a scalpel the full length of the uppermost side along its middle line, from the tail fin to the joint in the shoulder girdle. The shoulder hinge is cut through with a cartilage knife or bone cutter. A cross incision is made along the end of the tail fin where the skin joins it. The corners are laid back and the base of the fin bones are cut through with bone cutters, care being taken not to damage the skin of the other side of the tail. The body is now carefully removed from the skin, using a dull knife. The end of the tail is peeled free from the skin. The skin of the side is peeled away from the body on each side of the long incision until the centre of the back and belly are reached. A considerable amount of the roots of the fin bones are dissected and cut free from the body, leaving 1/4 or 1/2 inch of the roots intact on the fins. Again the end of the tail is lifted and the body is gradually separated from the prone skin. When the skin is freed as far as the shoulder girdle, the carcass is laid

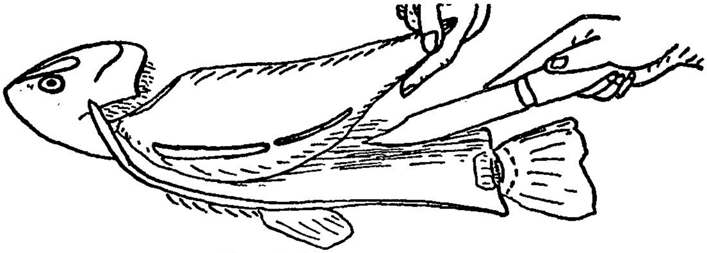


FIG. 20. SKINNING THE FISH.

back in the skin. The body is now cut free from the skin at the shoulder girdle, using a large pair of scissors or bone cutter. The point of attachment of the chest is left unbroken at the throat. The skinned body is now laid on the brown paper alongside the superficial contact sketch, and a contact outline is made of it. Th eyeballs are now removed by scooping them out with a curved scraper. The rims of the eye-sockets are cut around inside to open the way for removing the cheek muscles. A round-ended table knife is used to release the cheek skin from the meat, and a curved scraper to remove the cheek meat. The skull is left intact but the brain case is nipped out with a bone cutter. The skull bones are scraped clean and arsenical paste (see Appendix B) is rubbed in well over the skull and gills. The skin that covers the long interior muscles in the lower jaws is slit and all the meat is scraped out. Arsenical paste is rubbed in. The roof of the mouth is left intact and rubbed with arsenical paste. The body skin is now spread open and all meat and fatty tissue sticking to it are scraped away. The skin

should be scraped from the end of the tail towards the head, using a dull tool. Special attention should be paid in removing the flesh that spreads fanwise over the butt ends of the tail fin bones. Arsenical paste is rubbed in well inside the skin all over, and also on the fins; while the artificial body is being prepared, the arsenic-cured skin may be kept rolled up in an extended position in a piece of oil cloth or wax cloth.

Making the Artificial Body.—The contact body outlines of the fish are now taken, and just inside the full-figure body outline, a heavy black inline is drawn. The brown paper is now cut out along the black line, thus making a pattern for the mannikin. This will correspond more or less to the contact outline of the skinned body. The paper pattern is now traced around on a piece of ply-wood or thin 1/2 inch dealwood board. This board will be the core of the artificial body. This wooden core is now sawn out. A small block of wood may be screwed at the middle on the side of the board which will face the panel on which the fish will be finally mounted, if it is desired to drive in rings or hooks for support. A row of five little flat-headed nails is now driven half way in all round the edge of the core-board, to hold the thread or twine when wrapping the tow filling. Fine tow is wrapped round the core-board in wads and shaped flat, and after tying an end of the twine to a nail near one end of the core the tow is wrapped uniformly round and round, looping the thread or twine back and forth from the edge of the belly line to the edge of the back line, drawing tightly as the work is progressing, making a smooth, neat artificial body with the tow. When both sides are completely wrapped, the nails are driven in snugly. A U-shaped wire handle is made, with both its ends finely sharpened. This is set in the belly of the artificial body for holding it while applying the papier-mâché (see Appendix B) surfacing over the tow, using a small trowel or a plaster-tool. The papier-mâché is worked well into the tow. The surface of the body is modelled to the natural shape of the real body, leaving grooves in the correct places for the fins. The body is then hung up by the wire handle to dry. When dry, the surface is smoothed with a file and sandpaper and a coat of shellac is applied over it.

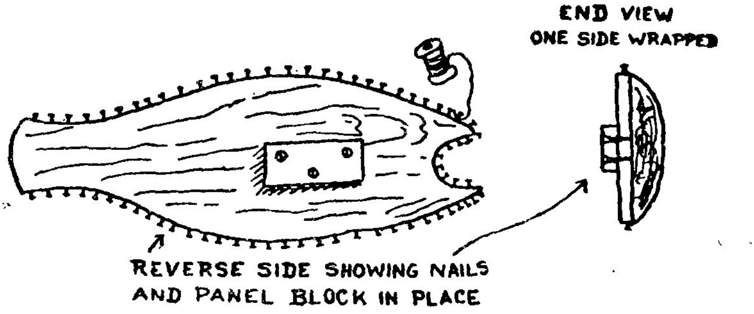


FIG. 21. BODY CORE FOR MOUNTING FISH.

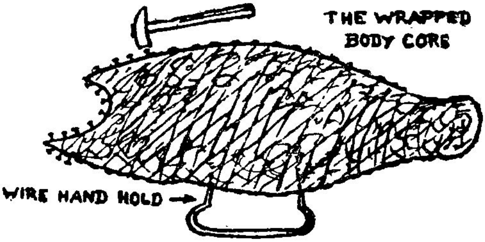


FIG. 22. WRAPPING THE BODY CORE.

Mounting.—The fish skin may now be pasted to the artificial body or it may be put on without any adhesive. If it is desired to paste the skin, glue mixed with flour paste may be brushed all over the inside of the body and tail on the skin. The artificial body is laid in the skin and the roots of the fins are fitted into their corresponding sockets. The skin is pressed lightly into contact with the artificial body and the body incision is now sewn up, beginning at the tail end. A sharp, three-cornered needle is best for sewing fish skins. It is advisable to rub the sewing thread with wax before sewing. The skull and the throat are set on the two projecting points at the front end of the artificial body. The cheeks are carefully stuffed with fine tow. The jaws are propped open with a wrapped ball of tow and the ends of the upper and lower jaws are pinned on to this mass of tow. The gill cover is raised on the view side of the fish, blocking it open with tow in the same way as the mouth. The gill cover is pinned to the block. The fins are prevented from drying up by dampening them with borax solution, (see Appendix B) while working on the remainder of the fish. The fins are spread out and clasped between pieces of cardboard which are pinned together at the margins. Wads of cotton are placed under the gill cover and the fins to support the carding until they are dry. After adjusting the specimen and finally checking it up for any possible defects, the fish is set aside for a few days to dry (see Figure 23).

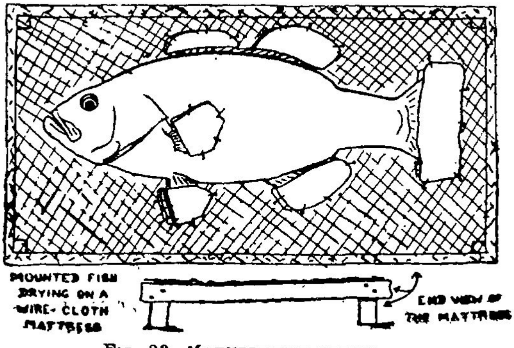


FIG. 23. MOUNTED FISH DRYING.

Retouching and Colouring.—A glass eye of the appropriate size and colour is set in the view side of the fish with a papier-mâché lining in the eye-socket. The parts around the mouth are modelled into proper shape by painting molten beeswax with cotton laid in the mouth parts and shaping it when cooled. The fin cards are now removed. Any tears in the fins may now be made up by giving a backing of glued tissue paper to the fins and trimming it when dry. The entire skin of the fish and fronts of the fins are now given a thin, even coat of shellac. When this is completely dry, the fish is painted in natural colours, using translucent tube oil paints and turpentine. The silvery iridescence of many fishes may be reproduced by giving a few touches of silver powder. Pearl essence in liquid celluloid may be used to simulate a pearly iridescence. When the paint is dry, a final coat of paper varnish may be given and the fish mounted on a suitable display panel.

Moulding and Casting a Fish—First Method.—Preparing a waste mould of the fish in plaster and casting it in plaster.

(1) *Preliminary preparations and moulding.*—The first step in preparing a plaster cast of a fish is to make a coloured sketch of the fish in water colours. The fish is prevented from getting dry by wrapping it with a moist cloth while sketching it.

All the fins are cut off as deeply as possible in such a way that there is enough of the bony roots of the fins left behind at the base of each of the fins and a corresponding hollow on the body of the fish. This serves for effective anchorage of the fins in the final cast. The fins thus cut away are soaked for a few hours in a saturated solution of borax to prevent future damage by insects. The eyes are also completely removed by cutting out the eye membrane and scooping out the eye-ball. If it is desired to retain the shape of the fish perfectly, the belly is slit open at the side opposite to the view side, the intestines and viscera removed and the interior stuffed with damp saw dust. The slit is then sewn up. This makes the body of the fish stay in perfect shape.

The fish is laid on a wooden board on one side, the more perfect and better-looking side being uppermost, and then adjusted in the desired position by placing little pellets of clay here and there underneath the body of the fish. A solution of alum (see Appendix B) which has been previously prepared for the purpose is painted all over the body of the fish several times with a soft brush. Care should be taken to see that the alum solution gets into every crevice of the fish. This prevents the skin of the fish from sticking to the plaster mould. After the skin is thoroughly washed with alum water, it is lightly wiped off with a piece of cloth and allowed to dry for a while and the surface is then given a coating of olive oil.

When this has been done, plaster of Paris (see Appendix B) in which some yellow ochre powder has been mixed, is prepared to a creamy consistency and poured all over the surface of the fish

in a thin layer and all excess plaster is removed from the sides of the fish. An even thin layer of yellow plaster thus forms a mould immediately over the body of the fish. Care should be taken to eliminate all air bubbles while pouring the plaster. In order to ensure this, the bowl of plaster is tapped on the table so that the air bubbles rise to the surface where they can be broken between the fingers. After the mould has set, a separator (stearic acid, soap solution or clay water of a creamy consistency) is applied over the mould with a brush. Plaster of Paris, without any admixture of yellow ochre, is now mixed and poured over the yellow mould, thus making a second mould over the first. This second mould is made a little bit thicker than the first.

When the second mould has set properly, the whole mould with the fish is taken off the board and the fish is pulled out from the mould. If the fish gets stuck up, it may be cut at the side, the head squeezed down and the whole body may then be pulled out. The inner surface of the mould is thoroughly washed and allowed to dry.

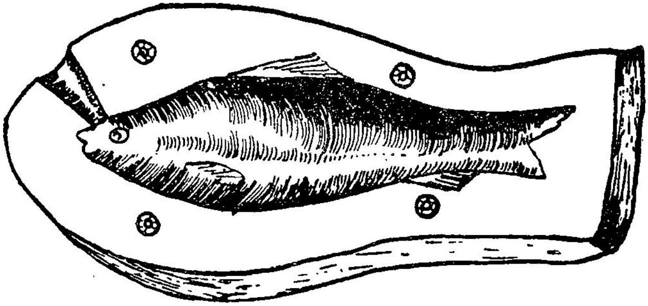


FIG. 24. PLASTER MOULD OF FISH (UPPER HALF).

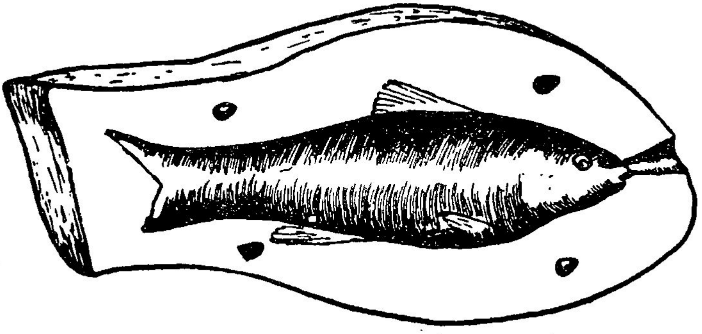


FIG. 25. PLASTER MOULD OF FISH (LOWER HALF).

Preparation of the Mould for Casting.—*Before pouring plaster* into the mould for making the cast, the mould should be prepared for casting in either of the two following ways :—

(1) The mould is soaked in water for some time. It is then taken out and the entire inner surface of the mould is coated with soap solution, liquid soap or green soap.

(2) The inner surface of the mould may be given a coating of shellac all over. Care should be taken to see that the shellac enters all the crevices of the mould. The gloss should be seen everywhere on the inner surface. When this first coating is dry, a second coating of shellac may be given and then allowed to dry again. The shellac should be applied in a very thin layer. When the shellac is dry, a coating of olive oil is applied everywhere on the inner surface of the mould with a brush. The shellac is to prevent the olive oil from getting absorbed by the plaster and the oil itself serves as a separator between the cast and the mould.

Casting the Fish.—When the mould has been thus prepared, plaster is mixed to a creamy consistency and poured into the mould, eliminating all air bubbles, first as a thin layer, which is made to run into all crevices of the mould so that a good impression is obtained. The plaster may be spread evenly with a soft brush or the surface of the liquid plaster may be blown.

If it is desired to make the cast hollow, only as much plaster as required to make a firm layer all round, is poured in. To reinforce the plaster, pieces of burlap (or gunny cloth) are cut up and placed over the first layer of plaster all over, and then the second coat is applied. A second laver of burlap pieces may be placed over this and a third coat of plaster applied over it and so on. This makes the cast very strong. In the case of small fishes the cast may be made a solid one by filling up the entire cavity of the mould with plaster. But in larger fishes, it is generally desirable to make it hollow to reduce the weight. While making the cast it is advisable to insert a pair of wire rings at the back of the cast, before it sets, to serve as hangers for the finished cast. When the cast is completely set, the mould may be carefully chiselled off. The outer heavy layer (white plaster) will easily separate off from the inner yellow layer, as a separator had been applied between the two layers. The inner yellow mould should now be carefully picked off bit by bit. Wherever it sticks hard, it may be carefully chiselled off, but great care should be taken not to injure the surface of the cast. When the cast has been entirely released from the mould, it is trimmed and modelled wherever there are irregularities such as air bubbles, depressions, scratches. etc. While modelling, care should be taken not to obscure the natural details of the cast.

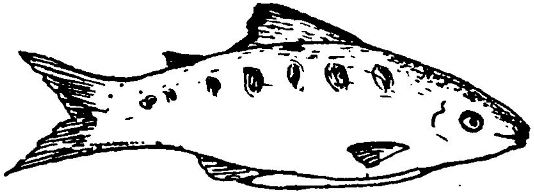


FIG. 26. FINISHED WAX CAST OF THE FISH WITH THE FINS FIXED IN POSITION AND PAINTED.

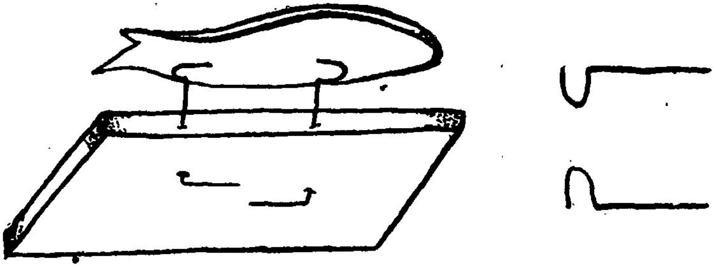


FIG. 27. METHOD OF MOUNTING CAST OF FISH WITH WIRE HOOKS.

Preparation of the Fins.—The fins are cut off as close as possible, leaving grooves of considerable depth in the body of the fish so that there may be sufficient depth in the cast for the insertion of the fins. As much as possible as the spine bones and flesh are taken away with the fins at their bases. The fins thus removed are soaked in a clear solution of arsenic or a saturated solution of borax for about three hours. They are then taken out of the

solution and allowed to dry in their natural position clamped between a piece of stiff cardboard and a sheet of cellulose acetate. Every fin is clamped and allowed to dry.

Fixing the Fins in the Cast.—When the fins are sufficiently dry and stiff (i.e., after about 24 hours) they should be fitted into the cast at their respective positions. Deep grooves are made in the finished cast of the fish at the proper places where the fins would fit in. They should be sufficiently deep so as to make the fins appear naturally fixed when inserted into them. The fins are first secured in position by celluloid paste and allowed to dry. The fins should be as close as possible to the front edge of the grooves so that they appear continuous with the body of the cast. The gaps in the fin grooves are filled in with molten beeswax, worked in by a wax tool and carefully modelled so that the joints look perfectly natural. Any broken parts of the fin membrane are repaired by pasting a backing of tissue paper coated with shellac to the hind surfaces of the fins and then trimming the edges to the desired outline. The edges may also be frayed out with a blunt tool to make the fins look more natural.

When all the fins have been thus repaired and trimmed the whole cast of the fish and the surface of the fins are given a coating of shellac. After it dries, a second coat of shellac is given and allowed to dry. The cast of the fish is then painted in natural colours with oil paints, using the original water colour sketch as a guide. Silver powder may be used in the finishing touches to give a silvery shine, characteristic of many species of fish. Finally a glass eye is set in the hollow on the cast at the position of the natural eye. The glass eye is fixed with a little melted beeswax which should be modelled carefully to form the 'eye-lid' round the glass eye.

Moulding a Fish in Plaster and making a solid Wax Cast from the Mould.—The fish is first prepared as for making a plaster cast. The fins are cut away as deeply as possible and soaked in a saturated soluation of borax. Some plaster of Paris is mixed to a creamy consistency and poured out on a soaped board to form an oblong layer (about an inch in thickness for small fishes, thicker layers for larger fishes). The fish is placed on its side over this bed of plaster and pressed gently, till half of its body is embedded in the plaster. As the plaster begins to set, the margin of the plaster adjoining the specimen is smoothed and levelled with a scalpel. When the plaster has set completely, the margin of the mould is trimmed roughly according to the contour of the fish, leaving a fairly wide margin all round the specimen. Keys (i.e., U-shaped grooves or conical pits) are cut in on the margins, about two on each of the longer sides, and the whole surface of the mould is given a liberal coating of liquid soap with a brush. Now a clay wall is built all round the mould and more plaster is mixed and poured over the first

mould with the specimen in position. When this second mould sets, it is trimmed at the margins to the size of the lower mould. The two moulds are now separated and the fish removed from it.

Casting.—An air groove is incised on the surface of one of the moulds from the part of the mould corresponding to the tip of the mouth of the fish. A deep channel is also cut out extending from the top of the head to the margin of the mould. This groove is made in both the moulds in such a way that they form a single funnel-shaped tube when the moulds are placed together. This tube is for pouring in the melted wax. If necessary, one or two more air grooves may be incised from the tips of the fins to the margin of the mould. The moulds are soaked in warm water for a few minutes, and then taken out and sponged with a towel to have all the excess moisture dried. The two moulds are placed together and beeswax melted in a double boiler (water bath) is poured into the cavity of the moulds through the opening in a steady, continuous stream, holding the moulds in a vertical position, until the entire cavity of the moulds gets completely filled and some of the wax overflows. The wax cast is now allowed to cool and harden. This process may be speeded up by keeping the moulds with the wax cast *in situ* under a running stream of cold water from a tap. When the cast has completely solidified, the two moulds are separated and the cast carefully released from the moulds. The cast is trimmed with a scalpel warmed over a spirit lamp. All the imperfections and irregularities in the cast are worked up and modelled with a wax tool or spatula (see Appendix A). The fins are attached in their respective positions and glass eyes are set in the eye-sockets. The wax cast is finally painted in natural colours with oil paints, using benzene as a thinner. If an air brush is available, the cast may be spray-painted. The paint should be put on lightly without obscuring the details of the cast. Silver powder may be dusted lightly on the cast in the case of fishes with a silvery gloss. When the paints are dry several coats of clear paper varnish may be given until the cast looks fresh and moist as in the living condition. The finished model may be mounted on specially prepared display panels by means of rings or hooks inserted into the less perfect side of the specimen.

Amphibians (Frogs, Toads, etc.).—Frogs are generally met with in fresh water ponds and in moist situations in the vicinity of pools and tanks. Toads as a rule inhabit drier regions and may be found in burrows or crevices of stones and rocks. Aquatic forms may be collected with a net, while terrestrial ones may be captured with long pairs of forceps. While collecting amphibians, it is desirable to look for their eggs and larvae. Many tropical frogs and toads deposit their eggs on the ground, in burrows, or on bushes or trees. Some carry their eggs or young, or protect them in nests made of leaves held together by a frothy secretion and often overhanging water. Most frogs and toads have distinctive mating calls

which the collector can learn to distinguish by experience. Many specimens may be tracked down at night with the aid of a powerful flash light by following their calls. This is perhaps the only possible way of obtaining the nocturnal and burrowing species. The rainy season is the best time to collect amphibians as most species appear above the ground during this season for breeding purposes.

Preserving.—The majority of frogs and toads and their larvae (tadpoles) are covered with a very soft skin. They should therefore be placed in weaker spirit than reptiles in order to prevent shrinkage of those parts which are particularly soft. Although 50 per cent alcohol may be used for the first few days, it is necessary to examine the specimens every day, as the alimentary contents tend to putrefy. The spirit must be changed three times at least, and often more frequently and finally replaced by 60 to 65 per cent alcohol in which the specimens may be permanently preserved. Care should be taken to inject the fluid well into the throat so that the interior is well permeated with alcohol. Before plunging specimens of frogs or toads into alcohol, it would be advisable to kill them with chloroform or by injection with veterinary nembutal. Formalin is not recommended as a preservative for adult amphibians, but it is preferable to alcohol for preserving larvae and eggs. If various stages in the life history of the frog are required, the eggs may be allowed to hatch in an aquarium and the larvae reared to various stages, killed, preserved in formalin and mounted on a glass plate in a specimen jar.

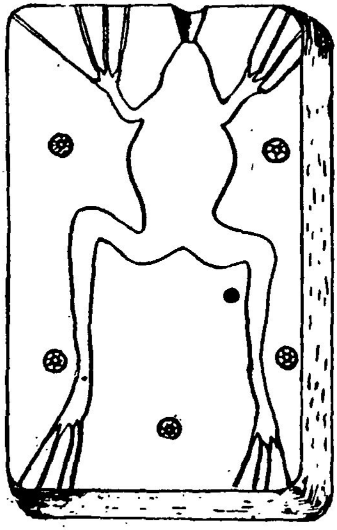


FIG. 28. PLASTER MOULD OF FROG, (UPPER HALF)

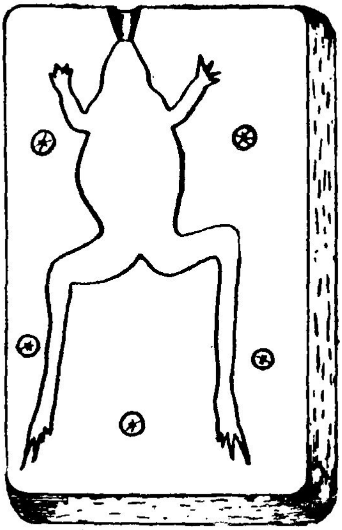


FIG. 29. PLASTER MOULD OF FROG, (LOWER HALF)

Preparation of Wax Cast of a Frog from Plaster Moulds.—A freshly killed specimen of a frog is laid on an oblong bed on plaster with limbs and toes properly spread out. When the plaster sets, keys are cut in, the surface of the plaster coated with soap solution and a second mould is prepared by building a clay wall all round and pouring plaster over the upper exposed half of the specimen. Thus a two-piece mould of the frog is prepared. From these moulds a wax cast is prepared in just the same manner as a fish cast is prepared. The cast, when completely set, may be dipped in warm water and the limbs carefully bent into natural positions. Finally, the cast is painted in natural colours with oil paints.

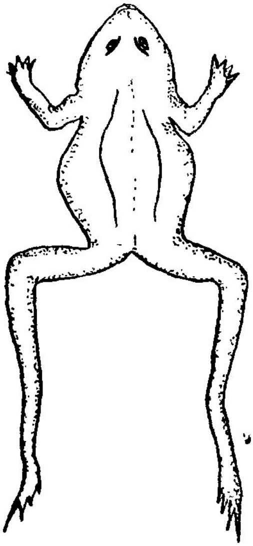


FIG. 30. WAX CAST OF FROG AS TAKEN OUT FROM THE MOULDS.

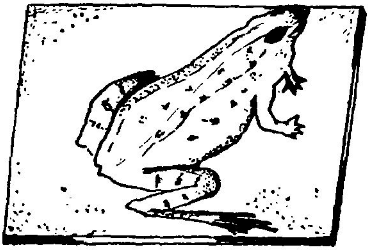


FIG. 31. WAX CAST OF FROG, WITH LIMBS BENT INTO NATURAL POSITION, COLOURED AND MOUNTED.

Preparation of Wax Cast of a Frog from Rubber Mould.—A frog is killed with chloroform or by injection with veterinary nembutal and posed in the desired position by means of strings suspended from a wooden frame (see Figures 32–35). A thin coat of liquid rubber (latex) is given with a brush all over the specimen of the frog. After one or two hours when the first coat has hardened, a second coat of liquid rubber is given, and so on, until a fairly thick, flexible rubber mould is obtained. Over the rubber mould, a plaster of Paris jacket is prepared by pouring liquid plaster, keeping the frog *in situ*. When the plaster jacket has set, slits are made along the ventral surfaces of the portions of the rubber mould corresponding to the belly and fingers and toes of the frog. Through the slit

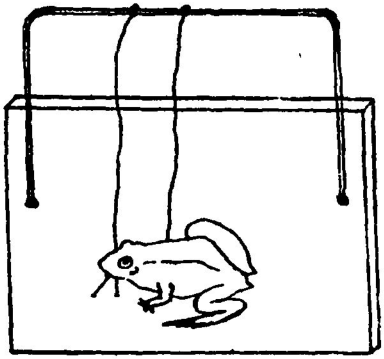


FIG. 32. POSING A DEAD FROG FOR RUBBER MOULDING.

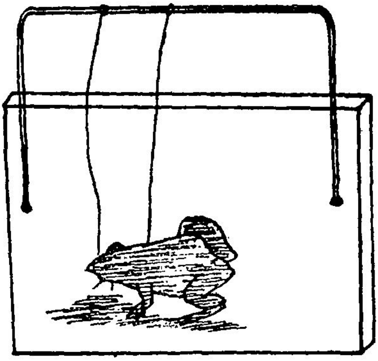


FIG. 33. FROG COVERED WITH LIQUID RUBBER (LATEX).

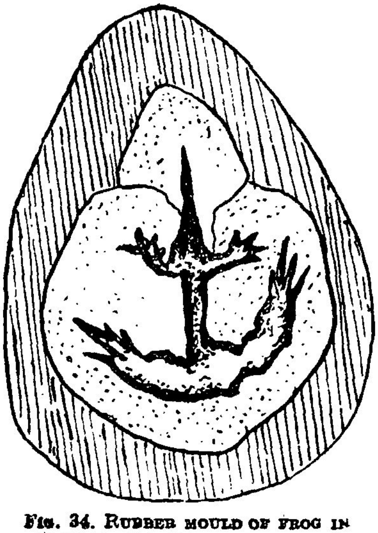


FIG. 34. RUBBER MOULD OF FROG IN PLASTER JACKET (VENTRAL ASPECT).

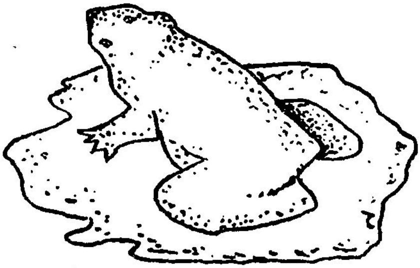


FIG. 35. RUBBER MOULD OF FROG REMOVED FROM PLASTER JACKET.

along the belly, the frog may be pulled out of the mould. The interior of the rubber mould is then washed thoroughly and given a coating of soap solution. Beeswax melted in a double boiler is now poured into the rubber mould and the mould rocked gently from side to side to let the wax penetrate into all the crevices of the mould. The plaster jacket will serve to prevent the rubber mould from bulging out of shape. A sort of a base for the frog may be built up by adding alternate layers of cotton and molten beeswax underneath the cast of the frog. When the cast and the attached base have set completely the plaster jacket and the flexible rubber mould may be removed, releasing the cast. The cast is finally painted in natural colours with oil paints.

Reptiles (Snakes, Lizards, Tortoises, etc.)—Collecting.— Reptiles inhabit various types of localities and it is difficult to lay down any general principles regarding their collection. Crocodiles are found in inland waters and at the mouths of large rivers. The best way to capture them is to shoot them with a 12-bore gun. Marine turtles and sea snakes may be obtained in nets with the aid of fishermen. Tortoises are generally found in tanks, ponds and rivers while the land forms with more convex carapace may be collected in moist localities adjoining meadows, marshes or paddy fields. Several of the larger lizards dwell in caves, crevices of rocks and on the hills. These can be best obtained by shooting with a revolver using very fine dust shot. The smaller species, however, are likely to be too severely damaged by even the finest shot and should therefore be caught by the hand or net. Some of the diurnal lizards can be trapped. A simple trap for catching lizards can be improvised from an empty kerosene tin from which the top has been removed and four stout wires arranged in the form of a cross fixed over the opening (see Figure 36). The centre of the cross has a small platform for the bait such as a piece of ripe fruit, and each of the arms radiating from it is threaded through a small piece of highly polished bamboo which is free to rotate. When a lizard attempts to cross to the bait (which may be rendered attractive by reason of the insects gathered round it) the bamboo turns and precipitates the animal into the bottom of the can. Nocturnal and cryptozoic (i.e., hiding) creatures can be found by a search of probable hiding places—dead logs, under bark of trees, underneath stones and in crevices of rocks. Provision of artificial hiding places will attract many species of lizards. Many species of snakes live habitually underground or are entirely nocturnal in habit. These can only be obtained by digging up the soil or by searching for them under stones or among decaying substances. Tree snakes are generally found entwined among branches of trees and are difficult to see as they harmonise with their surroundings perfectly well. Great care should be taken in handling sea snakes, vipers, kraits and cobras as they are all highly poisonous. Specimens of poisonous snakes may be best obtained by arrangement with local suppliers, villagers or jugglers and snake charmers who would be able to

procure them at a reasonable cost. Many snakes and lizards are adorned with brilliant colour patterns during life, but lose them after death. It is therefore advisable to make good coloured sketches of the animals in the living condition, before they are killed and preserved.

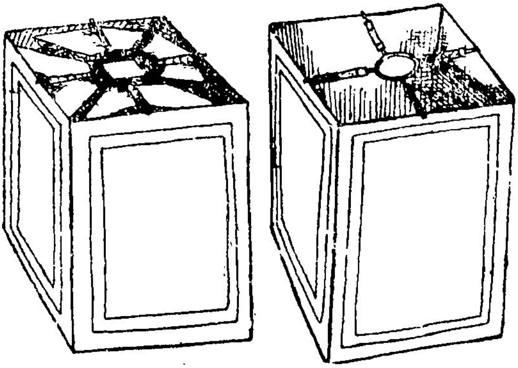


FIG. 36. EXTEMPORISED LIZARD TRAPS.

Preserving—Wet Preservation of Reptiles.—All reptiles should be preserved whole, wherever practicable. Except for very large reptiles such as marine turtles, crocodiles and snakes of more than 10 feet, most species of reptiles may be preserved in fluid. For the wet preservation of snakes and lizards for museum purposes, alcohol should be used wherever possible. The remarks regarding proper penetration of the preservative fluid and the successive changes of stronger percentage of alcohol, made earlier in connexion with the wet preservation of fishes apply equally well to reptiles. It is most important that the preservative should penetrate into the body cavity as rapidly as possible. The preservative may be injected at several points on the belly of the specimen by means of a hypodermic needle, but better results are obtained by making a series of small incisions along the middle of the belly. Incisions are particularly essential where the hinder food canal lies, as the undigested food causes putrefaction very rapidly. After passing the specimen through successive baths of 50 per cent, 65 per cent and 70 per cent alcohol allowing a few hours in each, the specimen may be permanently preserved in strong rectified spirit (95 per cent alcohol), but this final preservative fluid should be changed after 24 hours. The specimen becomes rigid in alcohol, but this can be overcome by manipulating the specimen for a few minutes twice daily for the first three or four days of preservation. If alcohol is not available 5 per cent formalin may be used for preservation but it is inferior to alcohol in every way.

There are many ways of killing a snake but this should be done with the least possible damage to the specimens. The simplest method is to break the spine a short distance behind the head by a blow with a stick. Snakes and lizards may also be killed with chloroform, and many of the smaller forms are extremely susceptible to nicotine, and a few drops of it placed in the mouth will kill them almost instantaneously. Living colours should always be noted and labels giving particulars of date, locality and habits should accompany the specimen. After preservation the specimens may be permanently stored in specimen jars if required for study purposes, but they should be properly mounted on glass plates and immersed in wide-mouthed jars if they are required for exhibition purposes. (see "Wet mounting"—page 59.)

Dry Preservation of Reptiles.—In the case of large reptiles such as crocodiles, turtles and large land tortoises and snakes of greater length than 10 feet and those of large girth such as Pythons and Boas, the preservation of the entire animal in alcohol is impracticable. Crocodiles may be stuffed and mounted, using an artificial body made of tow, in the same way as small mammals are prepared. To prepare the skin of a crocodile, it must be cut through along the middle of the under side, from the chin to the end of the tail. Care must be taken not to damage the skull. All flesh is scraped away from the inside of the skin and several handfuls of powdered alum and salt are rubbed into the skin on its flesh side. The skin may be left overnight wrapped in a gunny bag, and the flesh side should be scraped again the next day. Finally arsenical paste (see Appendix B) is applied all over the inner surface of the skin with a brush. Specimens of snakes of greater length than ten feet and those of great girth such as the Pythons are also unsuitable for wet preservation. They should therefore be skinned The animal should be split open along the whole median line of the belly, with a pair of strong scissors and the skin should be removed with a knife from the line of the cut towards the back. All flesh and fat are scraped away and arsenical paste (see Appendix B) should be applied all over the flesh side with a brush. The skin may then be rolled up with the scaly side of the skin outermost. If it is desired to preserve the skin in fluid the rolled up skin may be stored in a jar of strong (70 to 90 per cent) alcohol without applying the arsenical paste.

Preparing and Mounting a Tortoise.—The following method of stuffing and mounting a tortoise does away with the need for sawing the shell apart and wiring them together again. All incisions are made along the under side of the neck, legs and tail as indicated in Figure 37. The lower edge of the body skin is cut free from the plastron, leaving enough edge for stitching, from the neck incision outward to each foreleg incision, but not beyond. The same process is repeated from the tail incision outward to each hind leg incision. The neck, base of the head, the legs and tail are

skinned, leaving the leg bones and the skull attached to the skin. All flesh from the leg bones and skull is cleared and the eyeballs, jaw muscles and brain are removed. The joints should not be disarticulated, except at the shoulder and hip attachments in the shell. The entire fleshy contents of the shell are cleaned out with a long-handled scraper. Care should be taken to see that all dorsal muscles and flesh are removed from the roof of the shell. The interior surface of the skin and shell is thoroughly rubbed with arsenical paste and the shell is then spread out on its back to dry completely before attempting the mounting.

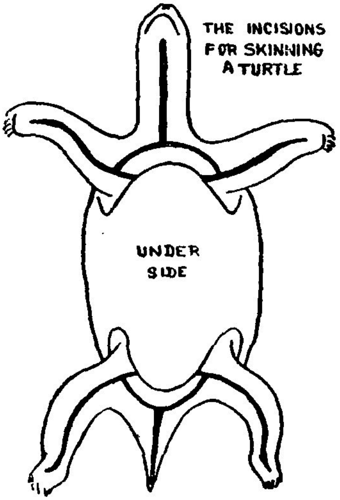


FIG. 37. SKINNING A TURTLE.

When ready to begin mounting, some beeswax is melted in a double boiler. Wads of tow are dipped into the hot wax, drained and laid on damp paper to cool. When ready for mounting, the skin is relaxed by applying arsenical paste to it repeatedly until it is pliable. The neck and tail cores are prepared by spinning cotton on wires cut long enough for anchorage through the shell stuffing. The leg wires are fastened to the bones in the same way as mounting a small mammal. The ends of all the six wires are sharpened. Bits of tow are wrapped on the leg bones to represent the muscle cores on the legs, binding them smoothly with thread.

The shell is stuffed full of the waxed tow, leaving a hollow at the front and back ends to receive the legs, neck and tail. The neck and foreleg wires are pushed backward through the body stuffing and the wire ends are clinched back into the stuffing at the rear end. The hind leg and tail wires are pushed forwards through the body stuffing and the ends are clinched into the stuffing at the front end.

The neck, leg and tail cores are covered with soft modelling clay. All incisions are sewn up with short stitches. The lower edge of the body skin is sewn to the corresponding edge of skin left along the front and rear margins of the plastron (i.e., the lower plate of the shell), where it was cut free. A few perforations are made in the skin of the neck, legs and tail between the scales with a needle to allow the clay to dry out. The tortoise is mounted on its base. The eye sockets are filled with clay and glass eyes are set in position. The neck, leg and tail details are moulded and the specimen is set aside to dry. When dried, any shrinkage should be replaced with wax. Faded colours are replaced with oil paints and a final coating of paper varnish is given over the shell.

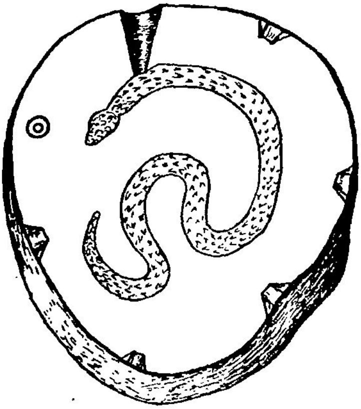


FIG. 38. PLASTER MOULD OF SNAKE (UPPER HALF).

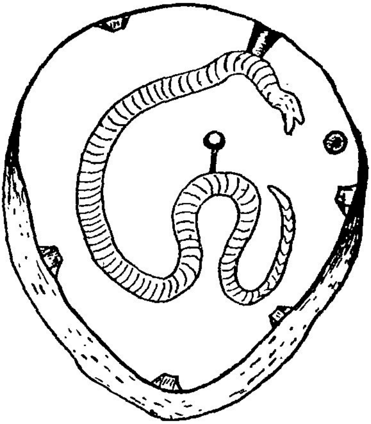


FIG. 39. PLASTER MOULD OF SNAKE (LOWER HALF).

Preparation of a Wax Cast of a Snake from Plaster Moulds—Moulding.—A large glass plate or wooden board is laid on the table and its surface smeared with soap solution. Plaster is mixed to a creamy consistency and spread on the soaped surface so as to form a rectangular layer of about an inch and a half thickness or more, depending on the girth of the snake to be moulded. It would be helpful if a rectangular plywood frame about 3″ or 4″ high is placed over the board as this will prevent the plaster from spreading at the sides. As the plaster is setting the freshly killed snake (which should be in a limp condition) is smeared all over with olive oil and placed over the plaster in the desired position and gently pressed down on this plaster bed until the ventral half of the body is embedded in the plaster. The snake is generally placed in a coiled, natural attitude. The edge of the plaster abutting against the body of the snake is levelled and smoothed off. The plaster is then allowed to set. When completely set, a few keys (i.e., conical or

V-shaped depressions) are cut in round the margin of the mould, and its entire surface is then coated with soap solution. A fresh batch of plaster is mixed and poured over the snake and the first mould, to make the second mould. While making this mould, it is advisable to lay the plaster over the specimen, little by little commencing from the head end and blow the plaster well so that a fine impression is obtained. When the second mould sets, the plywood wall is removed, and the edges and outer surfaces of the moulds are trimmed and levelled. The moulds are now separated and the snake removed from them.

Casting.—The moulds should now be prepared for casting. A fairly broad, shallow, U-shaped groove is cut on the marginal area of the lower mould connecting the free outer edge with the cavity formed by the impression of the snake at some convenient point, preferably towards the head end. The two moulds are placed together so that the keys fit in and another U-shaped groove is made in the margin of the upper mould, corresponding in position with the similar groove in the lower mould, so that the two grooves together form a funnel-like tube for pouring in the molten wax. Narrow, thread-like grooves are also cut in here and there connecting the cavity of the mould with the outer margin for letting out the air. A few of these grooves may be connected to a hole drilled through the plaster mould at some convenient point somewhere near the centre

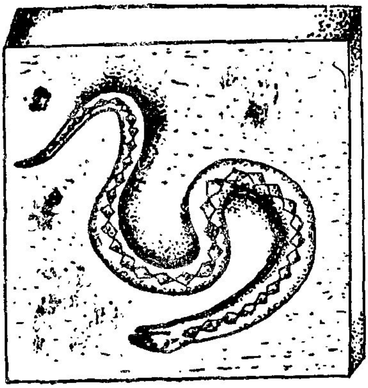


FIG. 40. WAX CAST OF SNAKE, PAINTED AND MOUNTED.

The two moulds are soaked in hot water for a few minutes, taken out, dried with a towel, placed together and tied up with a string. Pure beeswax melted in a double boiler is poured into the moulds through the opening of the tubular channel provided for the purpose. The wax is poured in a steady stream until the whole cavity is filled up and the wax overflows through the opening. The moulds are now set aside to allow the wax cast to set and harden.

The moulds may be kept under a jet of cold water to speed up the setting. The moulds are now carefully separated and the cast released from them. The knob of wax, corresponding to the tube through which it was poured, is cut away and the cast trimmed and all irregularities are carefully worked up with a warm wax tool or spatula. Finally the cast is painted lightly in natural colours using oil paints and benzene. When the paints are dry a final coat of paper varnish may be given over the entire surface of the cast.

Birds.— The preparation of birds for museum purpose requires a sound knowledge of taxidermy and sufficient proficiency in mounting birds can be achieved only by considerable practice and experience. The method of skinning and mounting a pigeon is described below, as a typical example.

Skinning and Mounting a Pigeon—Skinning.—The pigeon is killed with a few drops of chloroform and laid on a piece of brown paper and contact outlines of a few natural poses are made on the paper. Cotton is plugged into the mouth and vent and the bird laid on the table with the belly uppermost. The belly and breast feathers are parted along the centre of the body where a bare strip of skin shows plainly. An incision is made in the skin throughout the full length of the abdomen and breast using a sharp scalpel. Care should be taken to cut just through the skin, leaving the abdominal wall intact. The skin and body wall are easily separated. After making the incision, the skin is pulled free from the breast meat. Dry plaster of Paris should be sprinkled frequently to absorb any blood that may ooze out. When the thigh is exposed on one side, the leg is pushed forward inside of the cut so that the

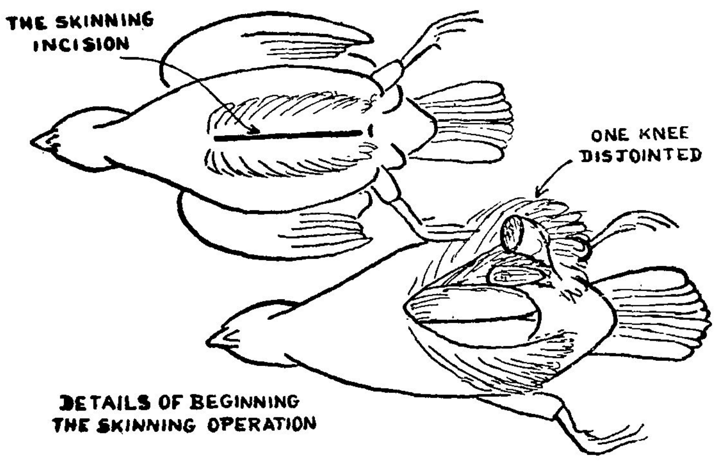


FIG. 41. SKINNING A PIGEON.

knee joint is brought to view. The knee is severed with a cartilage knife or scissors. The same process is repeated on the other leg. Care should be taken not to cut the skin on the other side of the knees.

The bird is now set up on the front end of the body. The tail is bent back and the tail flesh and bone are cut through just forward of the quill ends. Care should be taken not to cut the skin on top of the tail. The skin is now peeled down over the hips, back and sides, using a scalpel, wherever necessary, to cut the skin free. The skinning is continued down over the shoulders. The wings are pressed sharply forwards until the joints of the shoulders give away under the strain. The shoulder joints are cut through, one after the other, taking care not to cut through the skin in front. If blood starts flowing the veins are plugged with cotton and plaster of Paris is applied liberally.

The skin is peeled down over the neck and head. When the ears are reached, the points of the forceps pinched together are inserted forward of each ear and the whole lining is lifted out of the head without cutting.

The face skin is peeled out over the eyes, cutting the lid linings away close to the skull. The skinning is continued down to the base of the bill and the base of the skull is cut off with a cartilage knife, leaving the base attached to the neck. This opens the brain cavity and makes cleaning of the skull easy. The skin is now freed from the body.

The eyeballs, brain and jaw flesh are removed from the skull. The skull is rubbed with arsenical paste and all fat and flesh are scraped off from the neck skin. Arsenical paste is applied over the

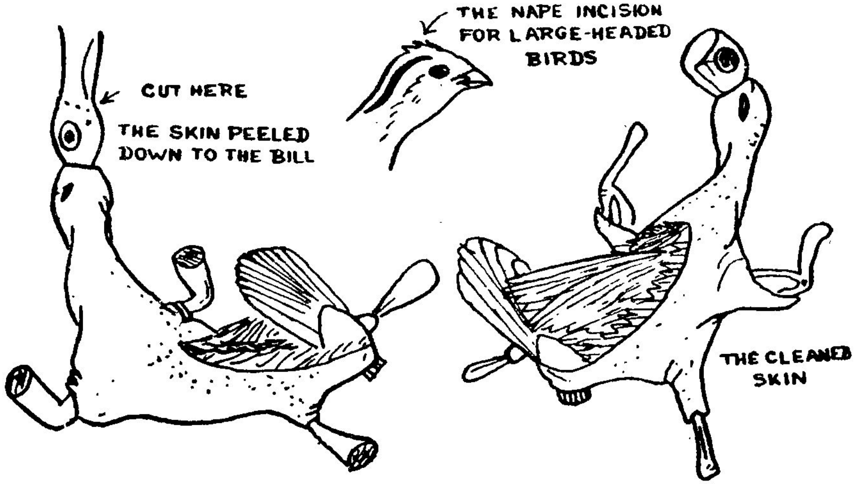


FIG. 42. FURTHER STEPS IN SKINNING A PIGEON

skin with a brush. All flesh is cleaned away from the leg, wing and tail bones. To clean out the legs, the skin is peeled down to the top of the bare part of the legs. The tendons are severed with a scalpel in front and back of the bone; then the cut ends are seized with a forceps and ripped from the bone in one motion. Any flesh that may be still adhering is scraped off and arsenical paste is rubbed on the bones.

The balls of the feet are split and the flesh and tendons are cleared out of the balls of the feet.

The skin of the wings is peeled down to the elbows. The tendons are cut through just above the elbows and the flesh is stripped from the upper arm bones. The forearm flesh may be removed by pushing the skin down over the fronts of the forearms in short-winged birds. Long-winged birds require a forearm incision to be made in the bare strip of skin along the middle of the underside. Arsenical paste (see Appendix B) is rubbed in all over the flesh side of the skin as the work is proceeding. Care should be taken to apply the paste liberally into all nooks and crevices including the cavity of the skull. Blood-stains on the plumage may be washed with weak ammonia water, using a soft sponge or piece of rag to work with. The skin should not be allowed to become dry during the process. The moist skin is kept wrapped up in a piece of wax cloth until the artificial body and the wires are prepared.

Mounting the Bird.—The first step in mounting the bird skin is to turn the neck and head inside out and stuff the eye sockets full of soft tow or cotton. Then a layer of cotton is wrapped over the top of the skull down over each side, and its margin is tucked in under the jaws. The head is turned back into the skin, making sure to stuff the front edge of the cotton layer down close to the base of the beak.

The second step is to make the artificial body. Tow is the material that is generally used for this purpose. For most types of birds having robust bodies, the pear-shaped or egg-shaped artificial body is recommended. The shape, when properly made and installed, requires little or no loose filling to be placed after the skin is laid over it.

To start making the artificial body, a handful of tow is wrapped into a club shape, more or less pointed at both ends. This is folded in the middle and wrapped together firmly to make an ovate body core. Around this body core flat wads of tow are wrapped, and this is continued till the pear-shaped form is obtained. When this is held over the contact sketch of the real body, it should approximately conform to the dimensions of the side view drawing made at the beginning.

The third step is to cut and sharpen the neck, leg, wing and tail wires. The wires for supporting the neck and legs should be strong enough so that there will be no wobbling of the finished

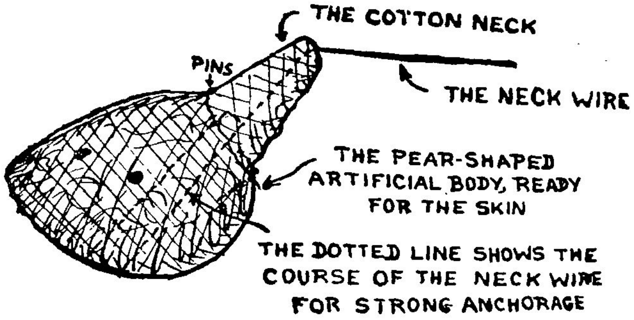


FIG. 43. ARTIFICIAL BODY FOR MOUNTING THE PIGEON.

mount. Temperless galvanised iron wire is the most practical. The neck wire is cut two and a half times the length of the body form, and is sharpened at both ends. The two leg wires are cut two and a half times the length of a leg from the knee to the ball of the foot. These are sharpened at one end only. Wing wires are generally used only when the wings are to be set in a spread out position, and may be dispensed with if the wings are to be kept closed over the body. But even in the latter case wing wires may be used to give adequate support for the wings. The two wing wires are cut twice the length of the wing from the shoulder joint to the end of the hand bones, and sharpened at both ends. The tail wire is cut one and a half times the length of the body. One end of it is sharpened and the other end is bent into a T-shape for supporting the tail quills. Some taxidermists do away with the tail wire altogether, and use long pins for supporting the tail feathers. Before inserting the neck wire into the body, the pose in which the bird has to be mounted should be determined. If the head is to be held high, an ink spot is marked at a point *above* the centre of the front end of the body. If the head is to be held low, the ink spot is marked at the centre of the front. The neck wire is pushed in at the ink spot and through the body lengthwise. The protruding end of the wire is turned back and clinched into the body.

A cotton neck is spun upon the wire in front of the body, winding the first layers of cotton tight and smooth. The remainder of the layers may be slightly looser, but they should be placed carefully and smoothly. Large bird necks may be made with tow cores wrapped down with thread, then finished with a cotton surface. All the outer layers of the artificial neck are wrapped with thread. The cotton neck is tapered and made just a little fuller than the real neck. At the top of the neck sufficient cotton is added to fill in the brain cavity. The neck layer first wrapped is pinned to the body to prevent the neck from slipping on the wire. The base of the neck is tapered out a little on the body and the last

layer is pinned in several places on the front of the body to hold it snugly in position. The positions of the shoulder joints, knee joints and tail attachment are marked on the body with ink spots. The wing bones are wired by slipping the wire along the back of the elbow joint. One point of the wire is probed out into the wing tip, through the cords under the wrist. The wire is wrapped to the upper arm bone with thread. The muscle shape is replaced with cotton smoothly wrapped over the bone. The forearm is stuffed with cotton and the incision is neatly sewn up. The same is repeated on the other wing, and the wings are bent half-closed.

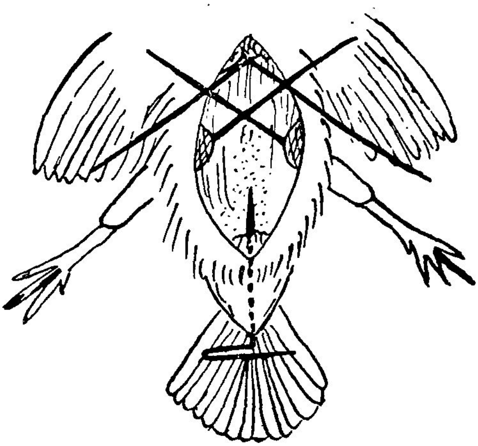


Fig. 44. Wiring the pigeon skin.

A leg wire is slipped up through the back of a leg until the tip of the wire is just beyond the top of the bone at the knee. The wire is wrapped to the bone with a few turns of thread. The leg muscles are replaced with a tapered wrapping of cotton. This is bound with a few turns of thread. The wire should slip freely to go through the body. The same process is repeated with the other leg. The tail wire is put in through the tail on its underside.

Assembling the Bird.—To assemble the bird, a little cotton is first wrapped over the tip of the neck wire so that it will pass inside of the neck skin without catching into it. The sharpened tip of the wire is pushed out through the top of the skull (or out through the mouth). The brain cavity is pushed on the end of the neck. The skin is drawn down over the neck. The wing wire ends are passed through the body at their ink marks and clinched

into opposite sides of the body. The body skin in pulled partly into place and the leg wire is passed on one side into the ink mark at the knee. The leg is worked back on its wire repeatedly and the wire is pierced through the body until enough of it comes out on the other side to be turned and clinched into the body. The knee is pushed down to the body. The same process is repeated with the other leg.

The tail wire is pushed in at its ink mark. The tail is stuffed with cotton and the tail is settled to the body. The wire is pushed in until the T-bend rests near the skin under the large quills, but not close enough to press the feather butts apart.

The legs are bent somewhat back along the body. The bird is picked up by its legs and shaken a little to loosen the feathers so that they will settle into place readily. The long breast incision is sewn. The legs are then brought back down to the standing position. A wooden base is drilled and the bird placed upon it, temporarily bending the leg wires from underneath, to hold the feet close to the base.

The wings are lifted a little and the body skin is adjusted under them, pinning it up in place at the arm pits. Where necessary, the skin is moistened before sewing.

The wings, neck, legs and tail are bent to suit the pose chosen. The plumage is then preened to its natural effect with forceps. When all the plumage is arranged and adjusted in natural position, the glass eyes are set in place with a little clay in the eye sockets, adjusting the lids with a needle point. The bill is tied up in the closed position with a loop of thread sewn through the nostrils, first placing a little cotton in the throat. The toes are pinned in place on the base.

If the wings are to be set in a spread out position, the flight quills are to be carded with long strips of thin pasteboard pinned across them, then supported on rolls of cotton held up with sharpened wires set into the sides of the body.

When the bird has been well-shaped and preened, the plumage is loosely bound from front to rear with fine thread, passing the thread round and round the bird in criss-cross directions

The specimen is set away to dry and is given an occasional check-up, while drying. When perfectly dry, the tints of the bare skin, beak and feet are replaced with tube oil colours, linseed oil and turpentine. The leg wires are straightened and the end of each wire is clinched into the perch or base where it will not show. The feathers are preened again. The bird is now ready for display.

Preparation of Birds for Study.—When birds are required solely for study purposes, they are better made up as bird skins as they occupy much less space. The bird is skinned and the skin poisoned with arsenical paste as described above. The bird skin, however, is not left flat, but filled out to the size of the body

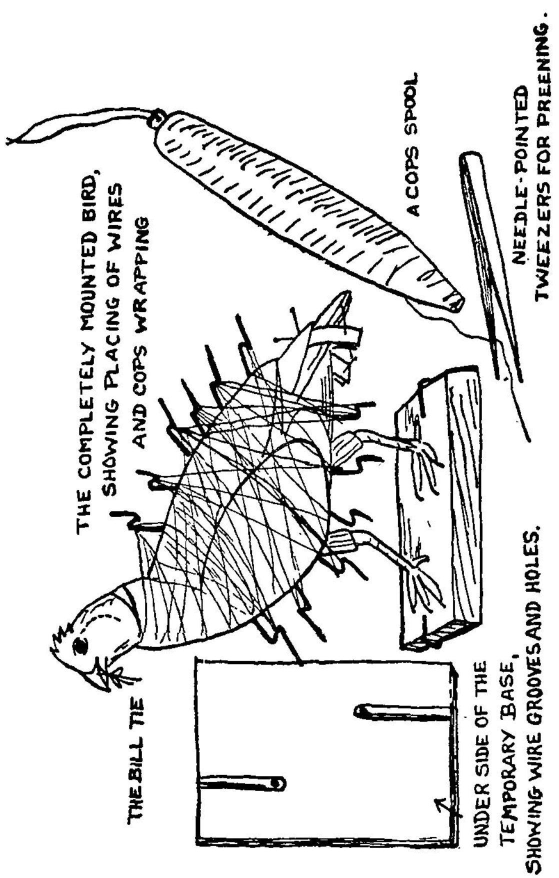


FIG. 45. MOUNTED BIRD SET ASIDE TO DRY.

removed, so as to show the relation of the plumage to the different parts of the body. First a fluff of cotton is rolled on to the end of a finely pointed forceps into a small, hard ball exactly the size of the eye. Taking the ball firmly in the forceps, it is passed up through the skin of the neck, through the back of the skull, and lodged in the orbit. Another ball fills the other orbit, and a little cotton in the brain space holds them firm. The eye-lids are arranged from the outside with a needle, as though the eyes were wide open, so that a smooth cotton surface shows.

THE COMPLETED SKIN

FIG. 46. BIRD SKIN PREPARED FOR STUDY.

The stuffing for body and neck is put in together. On a soft iron wire, somewhat larger than the required stuffing, cotton is first rolled in the form of the neck, tapering to a point anteriorly. Farther back more cotton is tightly rolled, until it approximates the size of the body removed. It must never be larger. The cotton neck protruding from the cotton "body" should not exceed the length of the bird's neck. The skin is now opened and the pointed anterior end of the stuffing (at the tip of the wire) is inserted, running it up the neck and into the throat, until its tip appears in the mouth. The skin of the bird is pulled back until it encloses the cotton body. The skin is properly arranged with the forceps, and the wings are folded close to the body. The general appearance of a finished bird skin should resemble that of a dead bird lying on its back. The posterior, projecting part of the wire is cut off and the incision of the belly is sewn up with a few stitches. The mandibles (i.e., the beaks) should be tied together so that the bill remains closed as in life. The thread may be passed through the nostrils with a fine needle, provided it does not injure them, and tied around the lower mandible. The legs are crossed and the toes extended moderately. A label specifying the date, locality and sex should be attached to the legs by means of a strong thread. Finally the skin is pressed and moulded in the palm of the hand and wrappped in a sheet of brown paper or a thin layer of cotton and stored in a cabinet.

Directions for Collecting and Preserving Birds' eggs.—It is important, while collecting birds' eggs, that the identity of the owners of the eggs should be properly established. To identify eggs for certain at least one bird leaving the nest should have been shot and determined. Particulars of the nests, their position and construction should also be recorded.

Preserving.—Fresh eggs can be easily emptied of their contents. A hole must be drilled with an egg drill on the side of the egg with the fewest markings. In the case of small delicate-shelled eggs, it is advisable to first prick a hole with a needle or pin before commencing to drill. The hole should be as small as possible

but should be large enough to allow perfect cleaning. When blowing an egg it should be held downwards over a bowl half filled with water. The point of the blowpipe is held close to, but just outside, the hole, and by blowing with force graduated in proportion to the size of the egg, the contents can easily be forced out. Clean water should then be drawn into the egg, by filling the blow pipe with water and blowing it into the hole. After thorough shaking and rinsing two or three times the egg is placed on some clean cottonwool or white blotting paper to dry, inspecting the egg occasionally, while drying.

Incubated eggs are much more difficult to be dealt with. In the earlier stages, the embryos may be broken up with a curved needle and macerated with warm water. After constant shaking up the entire contents may be removed bit by bit. Finally, the egg is thoroughly washed out and allowed to dry. When the egg is perfectly dry, a small piece of white paper may be pasted over the hole to keep out insect intruders.

Eggs should be marked with Indian ink as soon as possible with a serial number and, if known, the specific name of the bird together with the number of eggs in the clutch. Other details may be entered in a field diary against the corresponding number.

Mammals—Preparing and Mounting a Small Mammal (Field Rat)—Skinning.—The dead animal is posed on its side on a sheet of brown paper and contact outlines of several attitudes are made. After skinning the animal, outlines of the carcass, posed like the superficial drawings, are made. Dry plaster or Paris is used to dry up blood and body juices while skinning.

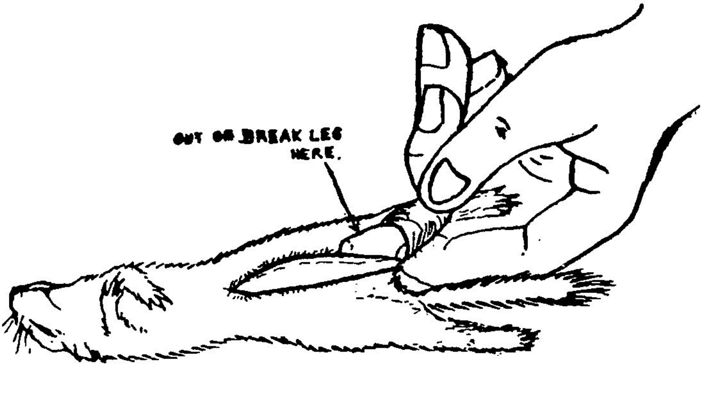


FIG. 47. SKINNING A SMALL MAMMAL.

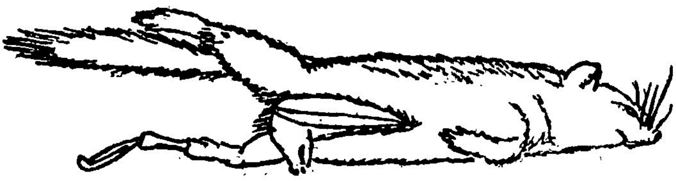


FIG. 48. SKINNING THE HIND LIMB OF A SMALL MAMMAL.

An incision is made along the middle of the belly from in front of the vent up to the middle of the breast bone. The body skin is peeled down over the hips. The hip joints and leg muscles are severed from the pelvis. The tail skin is peeled back on the tail far enough to afford a grip. The fingers and thumb nail of the right hand are set against the rolled back tail skin, the flesh at the base of the tail is gripped with the left hand and the tail is stripped out of its skin with a strong, even pull both ways.

The body skin is peeled down over the chest. The forelegs are severed at the shoulder joints and the skinning is continued on down over the head. The ear linings are cut deeply in the tubes. The eyelids and the lips are cut free close to the skull, so as to keep the linings entire with the skin. The skull is severed from the neck at its base, keeping it attached to the skin at the snout. All meat is cleaned from the skull and the eyeballs and brain are scooped out.

The lips are split, cartilage and tissue are cleaned out of the nose. Arsenical paste is rubbed into all parts as the work proceeds. Meat and tendons are removed from the undersides of the paws and feet through small incisions over these parts. All flesh is cleaned from the leg bones, but the joints should not be disarticulated.

Flesh and fat are carefully scraped off from all over the inside of the skin. Arsenical paste is rubbed in; the skin is scraped again thoroughly and a second coat of arsenical paste is rubbed in. A mixture of powdered alum and arsenic in equal proportions is also good for the skins of small mammals. The skin thus prepared is rolled up in an oil cloth while preparations are being made for the work of assembling.

Preparing the Artificial Body.—The paper sketches are now brought out. The legs are measured and soft, thin galvanised wires are cut for them twice the length from the toes to the shoulder and hip joints. These are sharpened at one end. The body wire should be a little thicker than the leg wires. The body wire is cut about twice the length of the body and neck combined. A wire is cut for the tail, a little longer than the actual tail. The body and leg wires are sharpened at one end and the tail wire at both ends.

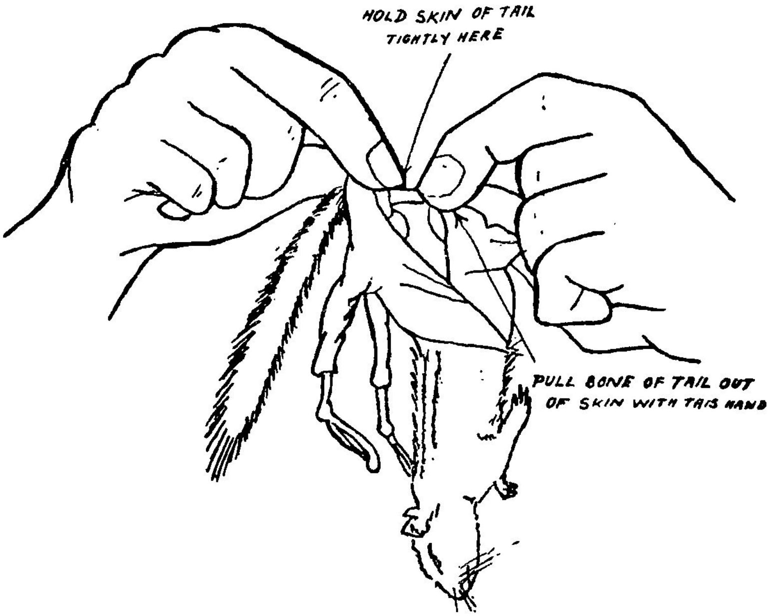


FIG. 49. SKINNING THE TAIL OF A SMALL MAMMAL.

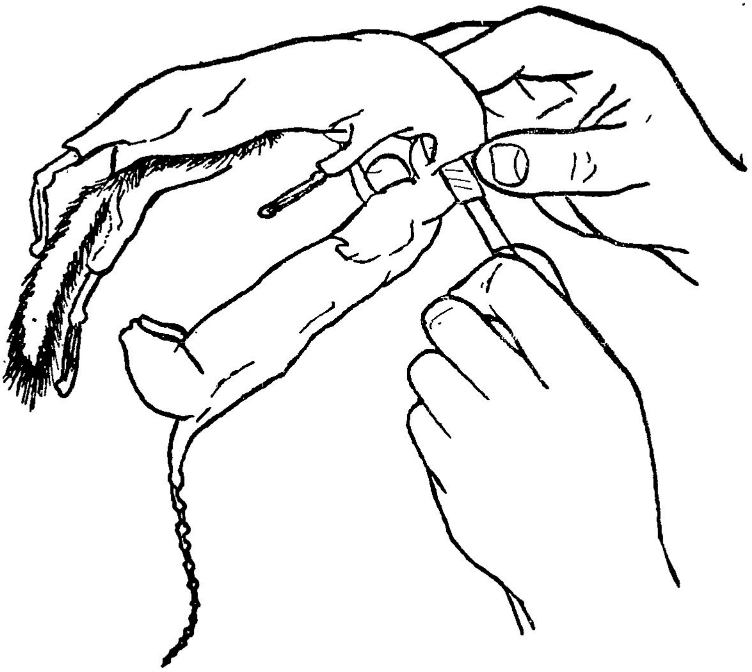


FIG. 50. SKINNING THE FORELIMBS AND NECK OF A SMALL MAMMAL

An artificial body is made by binding tow around the body wire, commencing from the blunt end of the wire. The tow is bound round and round with thread and the artificial body is moulded and shaped to approximate as far as possible to the shape and size of the real body, without the tail, limbs and neck.

Now, using the real tail for a model, a tapered artificial tail is spun round the tail wire with tow or cotton, commencing from one end of the wire and going up as far as the point where the butt end of the tail will be. The artificial tail is given a gradual taper. A couple of inches of the tail wire is left free in front of the butt end of the artificial tail. This should not be made too thick. It should be either exactly the dimensions of the natural tail, or just a shade smaller. Now the skin is turned hair side out, arsenical paste is painted on the artificial tail and its tapering end is inserted into the tail skin carefully and pushed up till the tip of the wire reaches the termination of the tail skin. The pointed end of the body wire is next inserted into the skull cavity and passed out through the roof of the skull and the artificial body is adjusted into proper position inside the skin. The sharpened end of the bare protruding part of the tail wire is inserted into the hind end of the artificial body at the natural position of the tail attachment. The skull is adjusted on the body wire and an artificial neck is wound round the front part of the body wire between the base of the skull and the front end of the artificial body.

The leg skins are turned inside out down to the toes for attaching the leg wires to the bones. The wires are bent to fit along under the leg bones. The wires are bound in place on the bones with thread. Three or four inches of wire are left to extend freely beyond the ends of the paws and feet for anchoring the specimen on a base.

At the shoulder joints the sharpened inner ends of the wires are inserted into the artificial body, passed out through the opposite sides and clinched back into the artificial body, adjusting the shoulder and the joints at the correct position and angles. The same process is repeated with the hind limb wires.

To replace the removed jaw muscles, tow is wrapped and stuffed over the skull, or soft modelling clay may be moulded over the skull to give the correct shape. To replace the muscles of the leg bones small wisps of tow are plucked to shapes resembling the thigh and upper arm muscles and these are bound in their correct places. The back parts of the thighs are left unfilled. These are to be stuffed with loose tow when the body is to be sewn up.

Before sewing up all hollow spaces are filled to the correct proportions with loose tow and the stuffed body is pressed and moulded into natural shape. The body incision is sewn up from the rear towards the front end, using short stitches and drawing up

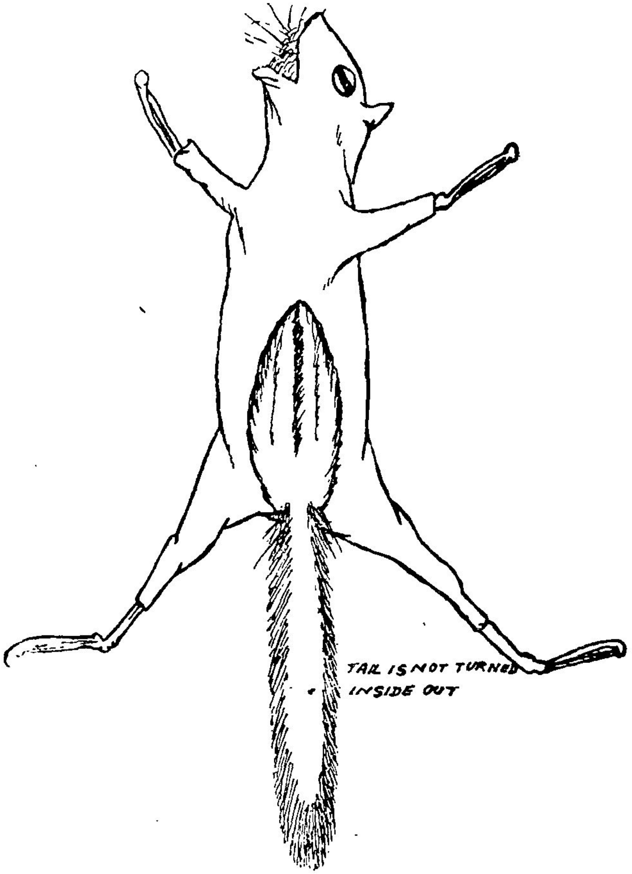


FIG. 51. COMPLETE SKIN OF A SMALL MAMMAL TURNED INSIDE OUT.

every two or three stitches tightly as the sewing is proceeding. Before entirely completing the sewing, the stuffing is checked to make sure that no more is required.

Holes are drilled in the perch or base to receive the leg wires. The animal is shaped somewhat into the attitude chosen and mounted on the perch.

Mounting and Finishing.—The leg wires are drawn snugly down under the perch and clinched to hold the feet in contact. The shaping of the specimen is completed. All lumpiness and irregularities are pressed out and all hollow spaces or lumpy spots in the body are adjusted and re-arranged.

The toes are pinned to grasp the perch naturally. The head should be kept wrapped in moist cloth until the rest of the specimen is completed.

The head is uncovered and a little clay is placed in the hollow of the ears or they may be held up with two strips of thin cardboard pinned together. The eye sockets are filled with gum and plaster and the glass eyes are set in natural position. The nose and lips are filled with a little papier-mache to bring them to natural form. The hair on the body is combed and the specimen allowed to dry: when it is completely dry, the eyelids, lips, nostrils and nails are touched up with a little oil colour and paper varnish.

Preparation of a Small Mammal for Study.—The following information is based on the leaflet issued by the British Museum (Natural History) on the preparation of small mammal skins:—

(1) The first step in preparing the skin of a small mammal for study is to write the label. This should bear on the front a serial number, date, sex, locality and altitude above sea level; on the back, the following measurements in millimetres should be given: (1) length of head and body; (2) of tail, (3) hind foot without claws; and (4) ear, from notch at base to tip.

(2) The skin is opened by cutting up the belly from the anus to the hinder end of the breast bone. First one knee is pushed and then the other knee through the opening and the legs are cut through at the knee joints. The chief muscles of the leg bones are cleared off, and the skin is separated away from the body all round the tail. Then holding the skin at the base of the tail firmly between the finger and thumb nails, the tail vertebrae are pulled out from inside with a pair of forceps. Then gradually turning the skin inside out, the skinning is continued over the body, shoulders and head, separating the forelimbs at the elbow joint, and taking great care not to cut it in passing over the eyes. It is skinned entirely off over the mouth, cutting carefully round the lips. Throughout the process plaster of Paris should be sprinkled freely to keep the fur unsoiled.

The inside of the skin is cleaned of all flesh and fat and brushed all over with arsenical paste.

The skin is turned back right side out and the cavity of the body is filled with cottonwool, putting it in, as far as possible, in one piece. Care should be taken just to fill out the skin without overstretching it. A piece of straight wire long enough to extend from the front end of the belly opening to the tip of the tail, is taken, one end of it is sharpened and enough cottonwool is wound round it to fill out the skin of the tail. It is then brushed with arsenical paste and the pointed end is pushed down to the extreme tip of the tail skin, and the near end is fitted into the belly, packing it round with the wool of the body. Some cotton is put into the empty skin of the arms and legs, winding it round the bones and

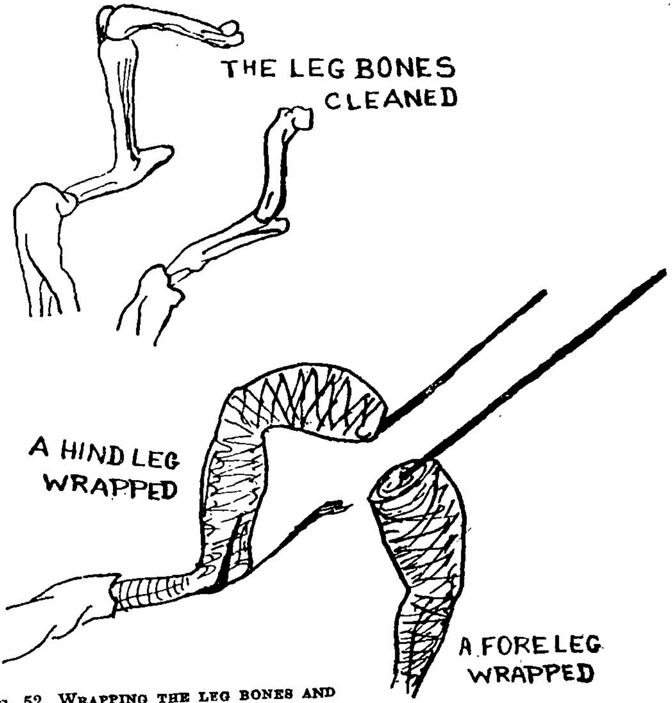


Fig. 52. Wrapping the leg bones and wiring them.

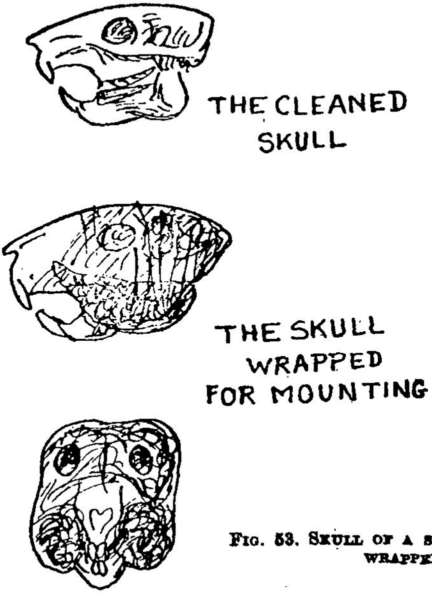


Fig. 53. Skull of a small mammal cleaned and wrapped for mounting.

connecting it with the wool of the body. The opening down the belly is stitched up and the label is tied to the right hind foot above the ankle.

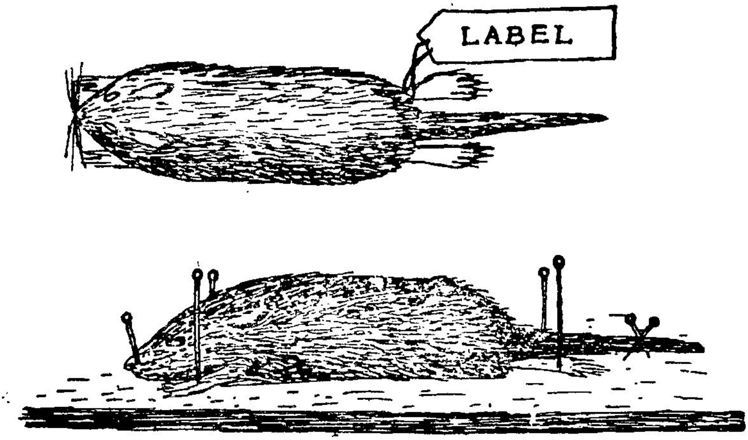


FIG. 54. COMPLETED STUDY SKIN OF A SMALL MAMMAL.

The skin is laid on a board or piece of cork, the fore paws are drawn out forward and pinned down to the board by a pin passed through the middle of the paw. Similarly the hind feet are drawn backwards and pinned down, *soles downwards* by the sides of the tail. It is important that neither the fore nor hind feet should project laterally outwards and that the fingers and toes should be kept parallel, not spread out sideways. As the skin begins to dry the face and ears should be adjusted and set so as to assume their natural shape. The skull is disarticulated from the trunk, the eyes and brain scooped out, and washed and dried. If it is dropped into saw dust, it dries up and little cleaning is necessary. The dry skull should be preserved in a muslin bag containing a little dry naphthalene and should accompany the study skin of the animal to which it belonged.

Mounting of Large Mammals.—The satisfactory mounting of large mammals requires an expert knowledge of piece moulding, casting and modelling and is generally beyond the ability of the amateur. The skinning is usually done as described for the small mammal, but it is generally necessary to skin along the under sides of the fore and hind limbs from the central trunk incision to their extremities, and the paws should be opened and cleaned of all flesh and tendons. The skin thus prepared should be properly tanned and the tanned skin should be placed over a hollow papier-mache mannikin or model of the carcass which is reinforced by iron rods for the limbs, trunk and neck. Tanned skins may also be preserved as such for study purposes.

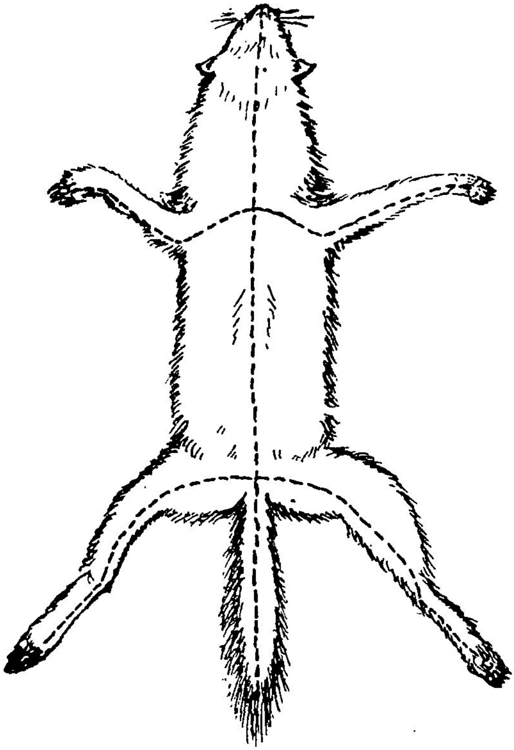


FIG. 55. INCISIONS FOR SKINNING A LARGE MAMMAL. (INDICATED BY THE DOTTED LINES.)

Directions for Tanning Hide (issued by the American Museum of Natural History).—(1) Soak the skin until it is soft in the following solution : 50 gallons water, 25 lb. salt, and leave it for 5 or 6 hours. Let the water-drain off. Rub several handfuls of salt on flesh side. Use dull side or back of carpenter's draw shave or back Roll in tight bundle and leave it overnight, covered with gunny cloth. (2) Scrape and clean all excess fat, blood, etc., from the flesh side. Use dull side or back of carpenter's draw shave or back of carving knife. A sloping wooden shaving beam (as shown in figure 56) will be found useful for scraping skins. Take care not to cut the hide. Dry hide in the shade. (3) Soak hide in the following solution. Dissolve in hot water 8 lb. of alum. Put 25 lb. of salt in 50 gallons of water. Add alum and mix. Soak hide for eight days for thick-skinned mammals such as bear, less for thinner-skinned animals. Take hide out, drain thoroughly and rinse for at

least 20 minutes. (Running water is handy). Taste hide for salt removal. (4) After washing all salt out, hang hair side out, first over suspended pole to dry for a day or two. Then hang flesh side out. Always work with hide in the shade. Do not dry in the sun. (5) Sprinkle hide with lukewarm water, tamping on with sponge to dampen (not wet) evenly. Fold flesh to flesh, roll and wrap in gunny cloth. Allow the hide roll to remain overnight. (6) Soften the hide in the morning, the way you soften a glove, by pulling over a dull edge. You can use a hoe blade or dull axe blade clamped in a vise. Be careful not to cut the hide. This should not take more than 15 or 20 minutes for softening. (7) Grease the entire flesh side of the hide with butter, lard or vegetable oil. (The Red Indians used the brain of the killed animal.) Rub in well and work the hide with the hands. (8) Place the hide in a barrel or basin and tread for two hours or more with bare feet, turning the hide over and over. This works the vegetable oil or butter into the hide and softens it with the warmth of the feet. Kick it around and tread it thoroughly to work the oil well into the hide. (9) Put the hide in a barrel with several shovels of hardwood saw dust and roll the barrel around to tumble the hide. This process removes the excess butter or oil, rendering the fur glossy and the hide soft. pliant and clean. Use only non-resinuous saw dust for this purpose. Then shake out the saw dust after the hide is cleaned and the skin has been well-tanned. Coarse sandpaper may be used on the flesh side of the hide to give a fine finish.

NOTE.—Be sure to stir all solutions at least twice a day to make sure that the hide is constantly touched by fresh solution. When tanning a small mammal the solution may be reduced in volume by using proportionately smaller quantities of salt, alum and water. It does not matter if you leave a skin in the tanning bath too long. It will not over-tan. But be sure that it stays in the solution long enough.

Preparation of Skeletons.—The skeletons of birds and small mammals may, as a rule, be prepared as ligamentary skeletons, i.e., with the various bones attached by their natural ligaments. The animal is first skinned, the belly opened and the viscera emptied. As much of the flesh as possible is scraped away, the skull is separated at its base and the brain scooped out with a brain spoon. The skeleton is then allowed to macerate in a tub of water for a day or two and the water changed frequently. The skeleton requires careful watching from time to time to prevent the ligaments giving way owing to over-maceration. The skeleton is then thoroughly washed in running water and soaked in lime water (chunam) for a few days and all flesh is cleared away by carefully scraping the bones. For thorough cleaning, the skeleton may be soaked in a solution of pancreatin or sodium sulphide with a steam pipe dipped into it so that the solution is kept at a temperature of about 180°F. (see Figure 57.) From time to time the skeleton should be lifted out and the feet, vertebral column and

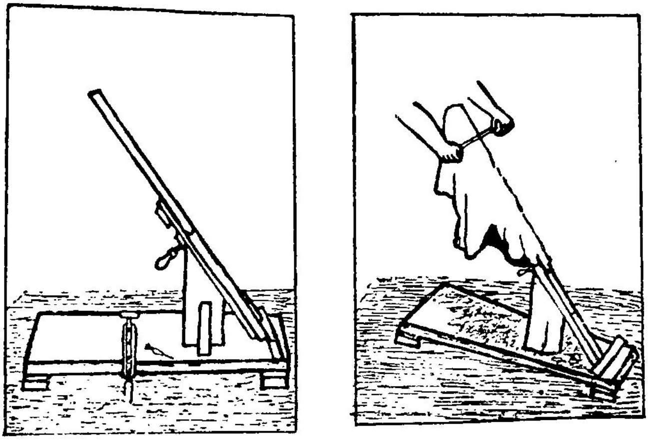


FIG. 56. SHAVING BEAM FOR SHAVING FLESH SIDE OF SKINS OF LARGE MAMMALS DURING THE TANNING PROCESS.

tail scratched smartly with small wire brushes. When clean, the skeleton is placed in warm water for a short time and then dried. It is then degreased by soaking in a jar of benzene or carbon tetrachloride and then bleached by immersion into hydrogen peroxide solution for about 24 hours. The skeleton may then be dried thoroughly in the sun. A wire is threaded through the neural canal of the vertebral column, and the skull fixed securely in position at the front end of this wire The ribs may be properly spaced out, with thin copper wire. The skeleton may be finally mounted on two brass supports fixed to a wooden pedestal. Detached parts of the skeleton may be secured in position with celluloid cement and teeth, which have become loose in their sockets in the skull should also be fixed up in position with the same cement.

The skeletons of large mammals should be prepared as disarticulated skeletons, i.e., with the various bones taken apart. The processes of maceration, cleaning, bleaching and degreasing are much the same as for small mammals and birds described above, but will take a much longer time in the case of larger mammals. The various parts of the disarticulated skeleton should be assembled in their proper positions when mounting, and the bones should be joined together by wire passed through holes drilled near their

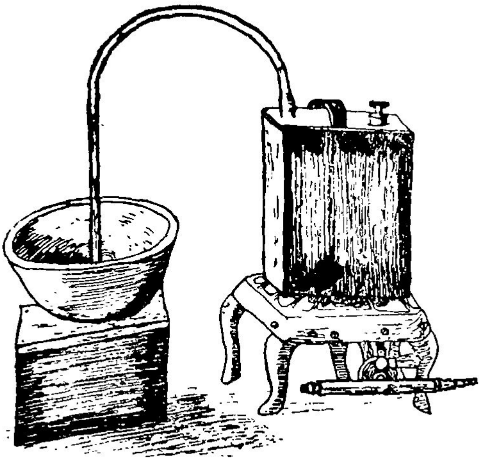


FIG. 57. APPARATUS FOR CLEANING SKELETONS. THE BOWL CONTAINS SODIUM SULPHIDE SOLUTION WITH STEAM PLAYING INTO IT THROUGH THE PIPE.

ends. The skeleton may be finally mounted with strong metal supports for the skull and neck and the pelvic regions on a strong teakwood pedestal.

Preparation of Enlarged Models of Animals.—Enlarged models are useful in cases where small and inconspicuous animals have to be displayed for museum purposes, e.g., mosquito larvae, house-fly, earthworm, etc. With the actual specimen and enlarged diagrams of the same, the model may be prepared either directly or by casting in wax from a plasticine model. The process of plaster moulding and wax casting from an original plasticine model is much the same as described for casting fishes and snakes. Direct modelling is done by painting melted beeswax with a brush over a core of galvanised wire armature wound round with tow or cotton wool, to the desired shape. After a great deal of trimming, shaping and modelling the final shape of the body of the animal is obtained. Appendages such as legs, proboscis, feelers, etc. (as for instance, in a house fly) should be modelled separately, on separate cotton-wound wire armatures, leaving enough of the wire bare at their proximal ends for anchorage and these should be fitted into the main body of the model at their correct positions. Wings may be reproduced by celluloid sheets with the nervures painted on them and fine glass beads may be used for simulating the compound eyes of insects. Fine bristles may be stuck into the model to represent hairs and the finished model is painted in natural colours with oil paints and turpentine.

Models may prove very useful in representing internal organs of animals, such as the heart, liver, lungs, etc., when such exhibits are required for illustrating lessons on food, respiration and other topics.

Wet Mounting of Zoological Specimens and Sealing Specimen Jars.—Zoological specimens which cannot be preserved dry should be mounted suitably in fluid if they are to be displayed for museum purposes. Wide-mouthed specimen jars with air tight ground glass lids of various sizes will be found useful for mounting zoological specimens. Small and light specimens may be mounted on glass plates with celluloid cement. The glass plate should be cut slightly narrower than the diameter of the jar so that it would slide easily down the middle of the jar. The specimen should be firmly pasted down with celluloid cement on the glass plate at its centre and allowed to dry thoroughly before immersion into the jar containing the preservative fluid. A thick white drawing paper cut to the required size may be placed at the back of the glass plate to serve as a background in the case of dark coloured specimens. For pale coloured specimens, the drawing paper background may be coated with black waterproof carbon ink and thoroughly dried before immersion into the jar. Larger and heavier specimens should be tied properly to the glass plate by means of silk thread threaded through the specimen with a needle at more than one point, but as the string shows, it is better to use mica sheets for these specimens. Two small holes may be pierced close together in the mica sheet and the thread from the specimen may be passed through these holes and tied up at the back. Two or more of such pairs of holes will be sufficient for mounting a specimen. The glass lid may be finally pasted down on the top with rubber solution or celluloid cement. Ox bladder soaked in water may be stretched in a thin sheet over the lid and drawn tightly over the rim of the jar and tied up securely with strong fine thread below the rim. The surplus portions of the bladder are trimmed away and the jar set aside in an insect-proof place to dry overnight. The next day when the bladder is completely dry, it may be painted over with black London enamel paint. Bladdering not only lessens the rate of evaporation of the preservative fluid, but also renders the appearance of the jar more pleasing for display purposes. Though celluloid cement or Dunlop rubber solution will ordinarily suffice for sealing specimen jars the following special cements used at the British Museum for sealing specimen jars may be tried :—

(1) *Glycerine-Gelatine Cement for sealing jars containing specimens mounted in Alcohol.*—Before sealing, the edges of the jar should be perfectly clean and free from grease and the spirit contained in the jar should be well below the top (about ½ inch). A small hole should be drilled through the margin of the lid, sufficiently big to take an ordinary blowpipe, for the purpose of filling the jar after sealing.

The drilled lid is now placed in the hot water bath to heat and a small quantity of the hot cement (see Appendix B) is carefully applied to the edges of the jar with a small hog-hair brush, taking special care that the cement does not run down inside. The lid is now removed from the hot water, hurriedly wiped (so as not to cool it too much) and placed on the glued surface of the jar. After allowing to cool for a minute or so, an additional coating of cement should be run round the outside edges in contact to fill up spaces where air would enter when the glycerine-glue contracts. An additional thin coat should be applied about two hours after sealing, again next morning, and again in the afternoon. The edges of the jar are now ready for trimming with a scalpel, care being taken not to trim too close to the cemented edges.

Spirit may now be introduced through the small hole in the lid, and a piece of cork fitted in the hole and cut off flush with the surface.

To obtain a better finish the edges of the jar may be painted with black enamel paint.

It is advisable to make up only a small quantity of this glycerine-gelatine cement at a time as the adhesive value of the gelatine is lost by continued heating.

(2) *Guttapercha and Asphalt Cement (for sealing jars containing specimens in formalin).*—The Guttapercha and Asphalt mixture (see Appendix B) is melted up in a ladle over a gas stove and stirred together taking care not to burn this cement. It is applied when liquid to the edge of the jar with a hot table knife blade. The edge of the lid which will be in contact with the edge of the jar is treated the same way, the lid heated over the gas stove till the applied cement is quite soft and then pressed down carefully on the cemented edges of the jar and smoothed round with the hot knife blade. Finally the edges are trimmed up when the cement is cold. As there is considerable difficulty in obtaining *old* Guttapercha of a suitable nature for making this cement, the substance known as 'Chatterton's Compound' proves a very efficient substitute. This is easily obtained from any chemical or electrical firm.

Dry-Mounting of Zoological Specimens.—Dry-preserved specimens such as sponges, corals, shells, dried starfishes, crabs and insects may be mounted dry in suitable plywood boxes with a glass top which may be pasted down with a binding of passe-partout or calico all round the margins. The interior of the box should have a neat white lining for dark-coloured objects or dark grey for light-coloured specimens. Heavy specimens such as coral masses or larger shells may be fastened to the back panel of the box by means of a thin wire passed through the specimen and out through two small holes in the panel twisted together at the back. Light specimens may be firmly pasted down or pinned in such a way that the

pins do not show. Boxes for displaying butterflies and other insects should have a cork lining pasted over with clean white paper. The insects may be pinned on to this cork lining. A narrow chamber with a perforated lid may be provided at one edge of the box for holding naphthalene powder especially in the case of insect exhibition boxes. The passe-partout chosen for binding the glass top to the box should be of good quality and of a pleasing colour.

Preparation of Accessories such as Grass, Foliage, Rocks, etc., for Habitat Groups—Preservation of Grass.—Most grasses are easily preserved in the Glycerine-formalin solution (see Appendix B). This solution is also suitable for preserving tough-textured leaves such as palm leaves, cacti, etc. The material preserved in this solution, loses its colour and emerges darker. When all excess moisture is evaporated, the grass should be wiped carefully to remove dust, and a coat of oil colour applied, preferably with an air brush. The first coat should be much lighter in tone than the final colour and should contain some body white. When this is thoroughly dry, the final coat is applied with transparent colour. Oil paint is heavy and should be used as sparingly as possible on delicate, preserved grasses, or they will sag into unnatural positions. In drying, it is advisable to hang the grass clumps upside down. Mosses also are readily preserved by this method. Grasses may be reproduced artificially by cutting wax-dipped celluloid into very thin grass-shaped strips, securing these to a wire and spraying transparent oil paint.

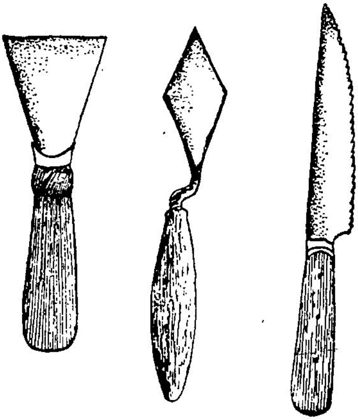


FIG. 58. TOOLS FOR WORKING WITH PLASTER.

Preparing Artificial Leaves out of Cotton and Wax.—A fresh leaf is posed face up on a bed of soft clay which can be moulded to conform to the contour and undulations of the leaf without pressing on the surface of the leaf and thereby destroying its details. When suitably posed, the leaf surface is cleaned with water by means of a soft brush and a clay dam is built around the bed of clay, leaving a margin of about three quarters of an inch, and plaster of Paris, mixed to a creamy consistency is poured over the surface, to a depth of about one inch. All air bubbles should be eliminated from the plaster. When the plaster is set, the mould is lifted off from the clay bed with the leaf intact, keys are cut in the margin of the mould, and after soaking it thoroughly in water, the whole surface of the mould is brushed with soap solution or a soft mixture of stearine and kerosene to prevent sticking. A clay wall is built around this, with the leaf surface of the mould uppermost, and again an inch of plaster is applied over the first mould with the leaf in position. When this is set, a two-piece mould is obtained. When many leaves are to be prepared, the moulds should be mounted in hinged clamps in perfect alignment

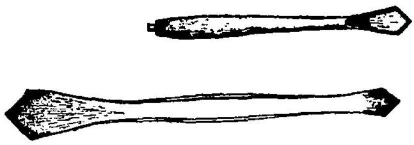


FIG. 59. TOOLS FOR CUTTING KEYS IN PLASTER MOULDS.

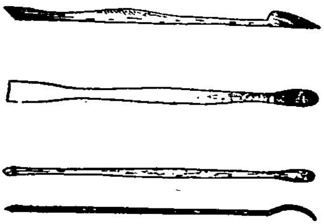
Thin galvanized wire is used to support the cast of the leaf. They should be cut into lengths about an inch longer than the leaf from the tip to the end of the petiole and of sufficient thickness to support the leaf without sagging. The wires should be tapered at one end, by tying them up into bunches and dipping one end of the bunches into strong nitric acid and draining alternately until the desired taper is obtained. The nitric acid is washed off and the wires are rubbed with fine sandpaper to remove the rusty deposit. Each wire is wound with a film of cotton, and, if the mould is undulated, the contour of the midrib is bent before beginning to press. Thin sheets of absorbent cotton form the base for the leaf casts. Pure beeswax melted in a double boiler is used to give the leaf body and detail.

The moulds are now soaked in water as hot as the hand can stand. They are then taken out and dried with a towel. A cotton-wound tapered wire is placed in the groove which represents the midrib, the tapered end being placed near the front end of the leaf mould. A thin sheet of cotton is placed over this and a sufficient amount of hot beeswax poured over this to insure the leaf surface being wholly covered. The clamp must be closed as speedily

as possible after pouring the wax, as this alone is the secret of making thin leaves. Very little pressure is required. The surface of the mould is moistened after each impression. The hot wax may be given a body colour by dissolving oil colour in it. Care should be taken not to overload the wax with paint as this may cause the wax to emulsify and make it unfit for use. Flake white colour and not zinc white should be used. A good general rule in casting wax leaves is ' Use a maximum of cotton and a minimum of wax '.

The excess wax is trimmed from the margin of the leaf by using slightly warmed scissors. If the margin is smooth then the trimming is accompanied by a sliding motion of the scissors. If serrate, the result is achieved by a choppy motion. The edges of the finished leaves should be thinned sufficiently to give a natural appearance, and this is best done by pinching the barest margin between the thumb and forefinger. A sliding motion of the thumb on the back of the leaf and the natural warmth of the hand accomplishes the desired result.

FIG. 60. TOOLS FOR MODELLING IN WAX.



In most cases, leaves are built into clusters after the character of the plant and these ' tips ' secured to the real branches. If the plant be small and succulent, then the whole assembly is built on to a wire stalk, which is modelled and bent, as the assembly progresses, to give the character of the plant. The individual tips of the leaf wires should first be soldered to a thick wire representing the main item which should then be wound round with cotton and coated over with melted beeswax and painted in natural colours with oil paints.

Preparing Artificial Leaves out of Celluloid.—A plaster mould of the upper surface of the leaf is made and sheet celluloid of suitable thickness dipped into dilute acetone, then into water and applied to the water-soaked surface of the mould with backing of water clay to hold it in contact until set. When removed, a tapered wire is dipped into celluloid cement and applied to the back along the midrib

Preparing Dry Leaves for the Groups.—Dry leaves for the groundwork in groups may be preserved by soaking in fairly hot water and then immersing in glycerine solution for a day. When

thoroughly drained, the excess moisture is evaporated and the leaves will be sufficiently flexible to stand handling without breaking.

Preparing the Groundwork in Habitat Groups.—The floor of the group case is first moulded to the desired contour by laying a sheet of wire mesh and nailing it down, supported by wooden struts of varying heights underneath. The surface of the wire mesh is covered with bits of burlap (gunny cloth) dipped in plaster. The surface of the earth, with twigs, dry leaves, small stones, etc., is then modelled. A mixture of cement and sifted ashes, about one to four parts, with dry colour added, if desired, is applied to the plaster surface, and the earth, etc., worked into this sufficiently to hold it in place and obtain a natural effect. Dry-preserved leaves may be scattered over this loosely, or if necessary to secure them, dipped into a diluted solution of glycerine and gelatine before applying.

In small habitat groups and dioramas a paste composed of plaster, asbestos, dextrine and whiting (see Appendix B) may be used in modelling the foreground. Dry powder colours may be mixed into it to give a natural effect. The paste remains soft sufficiently long to permit easy modelling.

Preparation of Artificial Rocks.—Rocks and stones may be prepared artificially by carefully modelling them from photographs. A piece of wire-mesh is folded and moulded after the contour of the rock and this is covered with bits of burlap or jute cloth dipped in plaster. The details of modelling and texture are added with plaster. A wet sponge, dipped in thin plaster, if skilfully handled, will give a rock texture, of considerable variation. Ground cork, mixed with the finishing coat of plaster, will be found useful in obtaining a coarse granite texture. Dry powder colour is sometimes mixed with plaster to give a base colour. But it is more convenient to paint the white plaster with diamond dyes after it has set. When the plaster is thoroughly dry, a light coat of shellac is given and the surface then painted with oil colours. Spattering the colour from a brush is usually more effective than spraying.

Artificial Representation of Water in Groups.—The portion that is supposed to represent the pond or the pool is first scooped out into a shallow hollow and a sheet of glass is installed horizontally over this hollow at the level which is supposed to represent the surface of the water. The shore line above the water is built separately from the main group base, including whatever objects there are which are to appear as projecting from the pool. Before sticking in the glass the bottom of the pool is painted dark green and whatever objects are to be represented at the bottom of the pool are placed there (e.g., stones, mosses, bits of leaves, etc.). Painting or flowing the surface of the glass with varnish or celluloid (coloured as desired) will enhance the watery appearance and give it a realistic effect. A slight clouding of the under surface of the glass will produce a deceptive effect of depth or of muddy water.

APPENDIX A.

TOOLS, APPARATUS AND MATERIALS.

For general collection of Invertebrates (other than Insects).

1 Bottles and tubes ..	Specimen tubes of various sizes with corks will be required for collecting small specimens. For the larger ones, wide-mouthed specimen bottles with air-tight ground glass stoppers or kilner jars with rubber washers will be useful.
2 Tins	Tins which may be closed air-tight by soldering will be useful for packing spirit-preserved specimens.
3 Dissecting instruments.	Forceps of various sizes, mounted needles, camel hair brushes, pipettes, scissors and scalpels. Long wooden forceps are useful, especially for marine collecting as they do not rust.
4 Dishes	Enamel, glass or porcelain dishes are useful for sorting out specimens before killing and preserving them.
5 Tools	Spade, shovel, rake, trowel, hammer, chisel, crowbar and buckets are useful, especially in marine collecting.
6 Sieves	Sieves of various calibre made of wire, horse-hair or muslin.
7 Haversack	A haversack and a cartridge belt to hold collecting tubes will be found useful for carrying small apparatus.
8 Miscellaneous	String, thread, gum, cottonwool, strips of stiff drawing paper and waterproof Ind an ink for labels, cardboard boxes, etc., will be required for general collecting work.

For special collecting : Land collecting.

1 Net	A strong insect net for sweeping vegetation will be required for collecting arachnids, etc.
2 Sheets of cloth ..	These are required to provide a light background against which small animals may be picked out.
3 Killing bottle	An entomological killing bottle, charged with cyanide may be used in killing small arachnids in the field.
4 Berlese funnel	(See Figure 3.) This apparatus is useful for collecting certain groups of animals (insects, myriapods, etc.) in bulk

Fresh water collecting.

1 Hand nets ..	These should be made of strong muslin or canvas and mounted on strong metal rings to which a handle can be attached. A diameter of about 9″ to 12″ is usually sufficient for the ring.
2 Metal Scraper	This is useful for scraping the surfaces of rocks, etc., and for working among dense weeds.
3 Dredge	A dredge is required for collecting on the bottom in deeper water. It consists of a coarse bag or net supported by an oblong frame of metal and is tagged on to a boat.

4 Tow net .. .. This is used for collecting floating organisms in deep water. It consists of a conical bag of linen attached to a circular frame which is fastened to a line by three cords. The net may be dragged through the water behind a boat.

For marine collecting also, various dredges, trawls, nets and other collecting apparatus are used, for fuller accounts of which the reader is referred to "Science of the Sea" (Second edition, Oxford, Clarendon Press, 1928).

For collecting and preserving Insects.

1 Beating sheet, tray or umbrella .. .. Many insects will fall to the ground if the branches of trees or shrubs on which they are resting are sharply knocked with a heavy stick. To facilitate the collection of these fallen insects, a white sheet may be spread on the ground beneath the foliage and the insects picked up with forceps. An umbrella with white cloth held upside down under the foliage will serve the same purpose.

2 Berlese funnel (Figure 3). This apparatus is used to collect the small insects that occur in the soil, vegetable, rubbish, etc. The principle is that the rubbish is held in a wire-bottomed tray over a funnel. The insects pass out of the rubbish down through the wire-bottom and fall into the cone which guides them into a jar or tube containing alcohol or other killing fluid.

3 Brushes .. .. Camel-hair paint brushes are useful in picking up small insects from decaying logs of wood.

4 Collecting Bottle .. This is a special form of killing bottle, with a strong glass tube having a bevelled edge passing through the cork. Small insects are passed into the bottle down the tube, which is closed with a small cork. The large cork is removed to empty the bottle.

5 Forceps .. .. Entomological forceps made with specially shaped points are used for handling pinned insects. Forceps with fine points are required for handling insects when packing or sorting them.

6 Cyanide killing bottle (Figure 1 B). A wide-mouthed glass bottle with an air-tight lid and layer of potassium cyanide and tissue paper about 1 inch thick at the bottom is used for killing insects. The cyanide layer may be covered with two or three circular sheets of blotting paper.

7 Chloroform killing bottle. A wide-mouthed bottle with a tight-fitting lid and a false bottom of wire mesh below which is placed some cotton wool soaked in chloroform may also be used as a killing bottle for insects. The insects are dropped over the wire mesh.

8 Knives .. .. A good pocket knife is essential for collecting. Scalpels of various sizes will be handy.

9 Lamps .. .. .. Electric light, where available, or petromax lights may be used for attracting insects at night.

10 Lenses .. .. .. A pocket magnifying lens is necessary for field work in entomology.

11 Light traps .. .. A variety of light traps are used for catching insects, Figure 2 illustrates a simple form. The insects are attracted by the light and are then held captive by the glass baffles. In this position they may be killed by fumes from a killing bottle placed as shown in the figure.

12 Mounted needles .. Needles mounted on wooden handles will be required for manipulating insects by most collectors.

13 Nets	For collecting insects on the wing, butterfly nets with an opening of approximately one foot in diameter will be required. The frame may be of metal, with a longer or shorter wooden handle fixed to it. Collapsible frames are more convenient. Sweeping nets used for brushing through herbage should have strong frames and handles and the net should be of a tougher material, e.g., unbleached cotton. Water nets with smaller frames and shallower bags are useful for collecting aquatic insects. Interchangeable frames and handles are convenient.
14. Cork setting boards: (Figure 1 E).	Grooved setting boards are required for setting butterflies and other insects with wings spread out.
15 Breeding cages ..	Glass cases with wire mesh tops are used for rearing caterpillars of moths and butterflies. They should be kept away from direct sunlight.
16 Scissors	Fine pointed pairs of scissors are required to cut open the abdomen of moths for emptying the contents.
17 Entomological pins ..	These are available in various grades of thickness and sizes and are used for pinning out insects prior to their permanent preservation.
18 Trowels	Strong trowels of the kind used in gardening are required for digging among rubbish, especially while collecting beetles.
19 Relaxing bottle ..	A wide mouthed bottle with moist sand at the bottom is used for relaxing insects before pinning.
20 Tubes	Small corked glass tubes are handy for collecting small and delicate insects in the field.

For collection and wet preservation of lower Verteberates (Fishes, Amphibians and Reptiles).

1 Fishing nets	A wide variety of nets for catching fish are available. Traps are also used for collecting certain types of fishes. The fisheries department will advise on these matters.
2 Long forceps	For catching amphibians and reptiles.
3 Lizard traps .. .. (Figure 36).	For collecting insects. These may be made from empty kerosene tins.
4 Spade	For digging up to collect burrowing forms.
5 Scalpels	For making incisions in the body of the animal before preserving.
6 Hypodermic syringe and needles.	For injecting the preservative fluid into the body cavity of animals to ensure proper penetration.

For Plaster-moulding, wax casting, modelling, etc.

7 Brushes	Thick, rounded country brushes are required for brushing soap solution, olive oil, etc., preparatory to moulding.
8 Rectangular frames ..	Plywood frames of various sizes are required for encasing the specimen prior to moulding.
9 Plaster tools (Figures 58 and 59).	A small mason's shovel, saw-edged knife, instruments for cutting keys in plaster, etc., are useful for plaster work.
10 Wax tools (Figure 60).	Steel tools with pointed and spatula-shaped ends are necessary for modelling in wax.

For Taxidermy, tanning, etc.

1. One large-sized cutting pliers.
2. One small-sized cutting pliers.
3. One small pointed-nosed pliers.

4. One pair of large scissors.
5. One pair of fine scissors.
6. One pair of fine forceps.
7. One pair of large forceps.
8. One large scalpel.
9. One fine scalpel.
10. One oilstone and a can of oil.
11. One bone cutter.
12. One cartilage knife.
13. One small hammer.
14. One drilling machine with drill bits of various sizes.
15. One small spatula or brain spoon.
16. One three-cornered file.
17. Mortar and pestle (for powdering arsenic, zinc oxide, alum, salt, etc.).
18. Ball of twine.
19. Reel of sewing thread.
20. Brown paper sheets.
21. Tow.
22. Nails, tacks, pins, etc., of various sizes.
23. Temperless galvanised wire of various grades of thickness.
24. Dealwood planks.
25. Glue.
26. Modelling clay.
27. Oil paints and brushes.
28. Paper varnish.
29. Glass eyes.
30. Cottonwool.
31. Wooden shaving beam for shaving skins before tanning. (Figure 56).
32. Large shaving knife with wooden handle on either side for shaving skins.
33. Saw dust.

Besides the above equipment, various traps, guns and rifles will be helpful in collecting birds and mammals.

For preservation of Birds' eggs.

1. Several brass blow pipes.
2. Egg-drills of different sizes—it is necessary to have spare ones as they become blunt with use.
3. A fine curved needle set in a handle for extracting embryos.
4. A fine eye-scissor and a pair of sharp-pointed forceps for dealing with incubated eggs of large size.

For preparation of Skeletons.

1. Apparatus for cleaning skeletons (Figure 57).
2. Large wooden tubs.
3. Glass jars (wide-mouthed).
4. Wire brushes.
5. Brass wire.
6. Galvanised wire of various grades.
7. Wooden pedestals.

APPENDIX B.

CHEMICALS, PRESERVATIVES, SOLUTIONS, ETC.

For general collection of Invertebrates (other than Insects).

1. *Acetic acid, glacial.*—A few drops of this added to solutions containing corrosive sublimate tend to prevent shrinkage of delicate tissues.

2. *Alcohol.*—Rectified spirit supplied by Messrs. Parry & Co., is 96 per cent strong. This may be diluted as follows:—

To ten volumes of rectified spirit add: for 80 per cent alcohol, 1½ volume of water; for 70 per cent alcohol, 3 volumes of water. 70 per cent to 90 per cent alcohol is generally used as a preservative for most animals.

3. *Caustic potash.*—A solution of this substance is used for cleaning the shells of Foraminifera. Immersion in a weak solution of this will protect steel instruments from rust during marine work.

4. *Chloral Hydrate.*—This is recommended as an anaesthetic for various groups of invertebrates.

5. *Chloroform.*—This is sometimes useful as an anaesthetic or as a killing agent.

6. *Corrosive sublimate (bichloride of mercury).*—This substance is used as a fixative, generally in a saturated solution in fresh water or sea water. This is extremely poisonous and great care should be exercised in handling it as its solution is colourless and odourless. It should be thoroughly washed out of the specimens in running water after fixation.

7. *Ether* is occasionally used as an anaesthetic.

8. *Formalin.*—The commercial formalin or 'formaldehyde' is 40 per cent strong. To one volume of it add 9 volumes of water for 4 per cent formalin which is the strength generally used in preserving soft-bodied invertebrates. The free acid in formalin is injurious for specimens that have hard parts containing lime. It may be neutralised by the addition of 5 grammes of borax to every litre of the full strength solution.

9. *Glycerine.*—In hot climates, or when some time is likely to elapse before specimens are unpacked it is useful to add glycerine in the proportion of about 1/20 part to the alcohol in which they are stored to prevent complete drying up of the specimens.

10. *Magnesium sulphate crystals.*—This substance is a very efficient anaesthetic for a large range of marine invertebrates.

11. *Menthol.*—This substance, in the form of crystals, is a good anaesthetic for marine worms.

12. *Oudeman's Solution.*—This is recommended for fixing and preserving terrestrial mites. A simplified formula is as follows:—

Alcohol (70 per cent.)	22 volumes.
Glycerine	1 volume.
Acetic acid, glacial	2 volumes.

13. *Perenyi's Fluid.*—This is a good fixative for marine bristle worms. It may be made up as follows:—

Strong nitric acid	40 c.c. or 1/4 pint.
Alcohol (90 per cent) ..	300 c.c. or 2 pints.
Chromic acid crytals ..	1½ gms or 1/5 oz. troy
Water	660 c.c. or 4½ pints.

These quantities give approximately 4 litres. In mixing, it is advisable to add the acid slowly to the water and not the water to the acid.

14. *Viets' Solution.*—This is recommended for fixing and preserving water-mites. It is made up as follows:—

Distilled water	6 volumes.
Glycerine	11 volumes.
Acetic acid, glacial	3 volumes.

15. *Saturated solution of Borax.*—For treating interior of crabs, sea urchins, etc., during dry preservation.

For Insects.

1. *Chloroform.*—Used as a killing agent in chloroform killing bottle.

2. *Cyanide of Potassium.*—Used as a killing agent in Cyanide killing bottle. Cyanide in all forms is extremely poisonous and the most stringent precautions should be taken in handling it.

3. *Preserving fluids and fixatives.*—Preserving fluids keep the internal organs soft and allow subsequent dissection. Fixatives render the tissues fit for histological investigation, but they become hard and brittle.

(i) *Preserving fluids*—(*a*) *Alcohol.*—70 per cent to 90 per cent alcohol is a general preservative for hard-winged, non-hairy insects.

(*b*) *Pampel's Fluid.*—4 parts by volume glacial acetic acid.
6 parts by volume formaldehyde (40 per cent).
30 parts by volume water (distilled).
15 parts by volume 95 per cent alcohol (rectified spirit).

The insects are killed with chloroform and then placed in this fluid with their body walls slit at some suitable point for penetration.

(*c*) *Chloral Hydrate.*—A 5 per cent solution of Chloral Hydrate is used for preserving insects killed with Chloroform.

(*d*) *Formalin* may be used as substitute for alcohol, but it is inferior to the latter for insects as their skins are hard.

(ii) *Fixatives.*—A great variety of fixatives are used. A good solution for general purposes is Picro-Chlor-acetic fixative made up as follows:—

12 parts by voulme 1 per cent of Picric acid in Rectified Spirit.

2 parts by volume Chloroform.

1 part by volume Glacial acetic acid.

4. *Disinfectants.*—Insects preserved and stored in storage boxes or cabinets must be protected from the ravages of pests. To ensure this the storage boxes should be treated internally with two or three applications of a disinfectant mixture. The following mixtures are commonly used:—

(*a*) *Lysol and camphor.*—A saturated solution of camphor in strong lysol.

(*b*) *Corbet and Pendlebury's mixture.*—This is made up as follows: In one part of chloroform dissolve 6 parts of powdered naphthalene and one part of creosote. Petrol may be added to increase the bulk. Cotton rolls soaked in the above solutions and mounted on long pins may be pinned in the corners of the cabinet drawers and storage boxes containing the insects.

(*c*) Naphthalene and Paradichlorobenzene may also be kept in narrow perforated chambers all round the margins of storage boxes and cabinet drawers.

For wet preservation of lower Vertebrates (Fishes, Amphibians and Reptiles.)

1. *Alcohol.*—For general museum purposes this is undoubtedly the best preservative. 70 per cent to 90 per cent alcohol may be used, but strong rectified spirit (96 per cent) is suitable for permanent storage.

2. *Formalin.*—For general museum purposes this is inferior to alcohol but a 4 per cent solution of this may be used when alcohol is not available.

For plaster-moulding, wax-casting, modelling, etc.

1. *Plaster of Paris.*—Bell brand plaster of paris should be used for general moulding and casting purposes.

2. *Pure Beeswax.*—Pure bleached beeswax may be used for casting. It may be hardened by addition of paraffin wax.

3. *Latex.*—Rubber in liquid form is used for making flexible rubber moulds.

4. *Alum water.*—This is prepared by dissolving one part of powdered alum in three parts of water. The solution is boiled and allowed to cool. It is applied over the scales of fishes prior to moulding.

5. *Olive Oil.*—This should be applied over the skins of fishes and reptiles before moulding to prevent the scales from sticking to the plaster.

6. *Liquid soap, Emulsion of soap in cocoanut oil or Shampoo.*—This is used as a separator between two plaster moulds.

7. *Stearine-kerosene mixture.*—This is also a good separator for plaster moulds.

8. *Saturated solution of Borax.*—For preserving natural fins to be stuck in the plaster or wax cast.

9. *White shellac.*—This is used for coating plaster casts before painting them in oil colours.

10. *Celluloid cement.*—Fine shavnigs of celluloid are dissolved in Amyl acetate to form a thick paste. It is used for fixing the fins in the cast. It may also be used for mounting specimens on glass or mica sheets in spicemen jars.

11. *Paper Varnish.*—For coating finally over the painted wax or plaster cast.

12. *Benzene.*—This is used as a thinner for mixing oil paint..

13. Plasticine or Modelling Clay is used for embedding specimens or building walls around them before moulding.

For Taxidermy, tanning, etc.

1. *Arsenical paste.*—This is prepared by mixing equal proportions of white arsenic (arsenious oxide), soap shavings and zinc oxide, adding a few lumps of camphor, dissolving to a creamy consistency in water, boiling and allowing the mixture to cool. The paste thus prepared may be stored in a jar and is the best preservative known for treating bird and mammal skins in taxidermy.

2. *Alum and salt.*—A mixture of equal proportions of powdered alum and common salt is used for tanning mammal skins.

3. *Vegetable oil.*—This is used for greasing the flesh side of tanned skins to render them soft and pliant.

4. *Benzene.*—This is used for washing out excess of fat from bird skins such as those of ducks, geese, etc.

5. *Plaster of Paris.*—This is useful in absorbing blood during skinning work.

6. *Modelling clay.*—This is used for giving the proper shape of the muscles over the artificial body in mounting mammals.

7. *Papier mâché.*—Severa' pastes are used in taxidermy. Paper plup and finely chopped tow may be added to casein glue and flour paste mixture to make papier mâché which may be used for shaping the details of the artificial body in mounting skins over the mannikins of mammals.

8. *Saturated solution of Borax.*—This is used by some taxidermists to poison skins of birds and small mammals as a substitute for arsenical paste.

For preserving Birds' eggs.

1. *Four per cent solution of Formalin.*—This may be used for washing out the interior of the egg shell after removal of the contents.

For preparation of Skeletons.

1. *Lime (Calcium carbonate).*—This is a useful cleaning and bleaching agent for skeletons.

2. *Pancreatin or Sodium sulphide.*—For cleaning skeletons.

3. *Benzene.*—This is used for degreasing skeletons.

4. *Carbon tetrachloride.*—This is also a useful degreasing agent for skeletons.

5. *Hydrogen Peroxide.*—This is used for bleaching skeletons prior to drying them in the sun.

For wet-mounting of Zoological specimens and sealing specimen jars.

1. *Celluloid Cement.*—Prepared as stated above (see under "Plaster casting") is useful for fixing up specimens on glass or mica sheets immersed in fluid in specimen jars. It may also be used for pasting the lid.

2. *Rubber solution.*—Dunlop rubber solution may be used for sealing specimen jars.

3. *Paraffin wax.*—Molten paraffin wax may be brushed over the lid for sealing specimen jars.

4. *Bladders.*—Ox bladder soaked in water and stretched may also be used for tying up lids of specimen jars air tight. May be obtained from slaughter houses.

5. *Enamel paints.*—Black London enamel paint should be painted over bladdered lids after the bladder dries up.

6. *Cement for sealing specimen jars containing alcohol*—

No. 2 Photographic gelatine	1/2 oz.
Prices' Best Glycerine	4 cc.

After weighing, soak the gelatine in cold water for 15 minutes, drain off the water and melt in a double boiler. When liquid, add glycerine and stir.

7. *Cement for sealing specimen jars containing formalin*—

Asphalt	4 parts.
Old perished guttapercha	5 parts.

Melt the above mixture in a ladle over gas stove and stir well together, taking care not to burn the cement.

For preservation of Grass, Foliage, preparation of Accessories, etc.

1. *Glycerine formalin solution for preserving grass and foliage*—

Glycerine	33 parts.
40 per cent Formalin	2 ,,
Water	65 ,,

This solution is suitable for preserving grass and foliage.

2. *Dextrine mâché for constructing groundwork in dioramas*—

Plaster	4 parts.
Asbestos	3 ,,
Dextrine	2 ,,
Whiting	1 part

All these are mixed with water to form a paste.

APPENDIX C.

FIRMS SUPPLYING CHEMICALS AND EQUIPMENT.

Most of the chemicals, instruments, appliances and materials listed in Appendices A and B may be obtained from one or other of the following firms:—

(1) Adair Dutt and Company, Mount Road, Madras.

(2) Scientific Instrument Company, Mount Road, Madras.

(3) Andhra Scientific Company, Mount Road, Madras.

(4) Premier Indian Scientific Company, Egmore, Madras.

(5) British Drug House, Nainiyappa Naick Street, Madras.

Paints and varnishes may be obtained from—

(1) Parry and Company, Dare House, Esplanade, Madras.

(2) Ambal and Company, Park Town, Madras.

(3) Bashyam and Company, Park Town, Madras.

Plaster of Paris may be obtained from:—

Messrs. Spencer and Company, Limited, Mount Road, Madras.

Rectified spirit may be obtained under a permit from—

Messrs. Parry and Company, Nellikuppam, Southern Railway.

Glass eyes, entomological pins, cork sheets, storage boxes and other equipment which cannot be procured from local firms may be obtained from the following foreign firms:—

British firms.—Flatters and Garnett, Limited, 309, Oxford Road, Manchester-13, The Entomology Company, 44, Great Russell Street, London, W.C. 1 and Watkins and Doncester, 36, Strand, London, W.C. 2.

American firms.—General Biological Supply House Inc., 761-763, East 69th Place, Chicago, Ill. U.S.A.

Wards' Natural Science Establishment Inc., P.O. Box 24, Rochester, N.Y., U.S.A.

APPENDIX D.

HELPERS.

1. Madras Government Museum, Egmore, Madras.
2. Fisheries Biological Supply Station, Ennur.
3. Department of Agriculture, Government of Madras, Coimbatore.
4. Department of Inland Fisheries, Chetput, Madras.
5. Government Veterinary Hospital, Vepery, Madras.
6. Public Health Department, Corporation of Madras.
7. Malaria Research Institute, Teynampet, Madras.
8. District Forest Officers and Forest Rangers in the various districts of the State.
9. Bombay Natural History Society, Apollo Street, Bombay.
10. Marine Biological Station, Krusadai Island, Pamban P.O.

APPENDIX E.

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Trustees of the British Museum (Natural History)—Instructions for Collectors—Handbooks—

(1) Invertebrates other than insects.

(2) Insects.

(3) Birds and their eggs.

(4) Reptiles, amphibians and fishes.

(5) Alcohol and Alcoholometers.

Wilwedring, W. J. Animal Drawing and Painting. Watson Gaptill, N.Y., 1947. Price $ 6.00.

SECTION II.

Plant Life—Collection and Preservation.

By M. S. CHANDRASEKHAR, B.SC., F.B.S.

(Curator, Botany and Geology Sections, Government Museum, Madras.)

Introduction.—Plants differ widely from each other in structural details, and have different seasons for flowering or fruiting. Further, the same plant does not grow at all places, nor do all plants grow at the same place. Structurally closely related plants may grow widely separated from each other. The difficulties involved in making a comparative study and appreciation of plants and their modes of living, do not require more amplification. The role of botanical gardens and greenhouses in this matter, no doubt, is magnificient; but with their limited scope, these institutions fall far short of meeting the needs of the students of Botany. It is therefore of utmost importance to keep the materials collected together at one place for study.

When making a collection, it is imperative to collect the specimens entire with root and all. If flowers, fruits, etc., are all available, the plant collected should show them all. Without these parts in entirety, the specimen will be imperfect and will become very difficult (sometimes impossible) of identification. There will be no difficulty in collecting entire specimens, if they are of a small size. Larger specimens will need some manipulations, if intended for the herbarium, since they should be able to go into the size of a *herbarium sheet* which usually measures 17½″ by 10½″. When difficulties are confronted in this regard, the best way of getting over them, is to collect the full plant and bend it to and fro as many times as necessary, provided (like grasses and ferns) it yields to such handling. When the plant is too large and brittle (like woody trees, shrubs, etc.), the only alternative is to have as much of the plant as possible from the ends of shoots or branches, and to collect and preserve representatives of the other parts separately. Should there be only a very small number of specimens of a certain plant in a certain place, they should on no account be collected, so that the stock in the place is not depleted.

Only the general and very common equipments for collection are described in these pages, leaving out the special requirements to the collector's own choice. Two essential equipments, *vasculum* and *portfolio*, are very important and even distinguish the botanical collector.

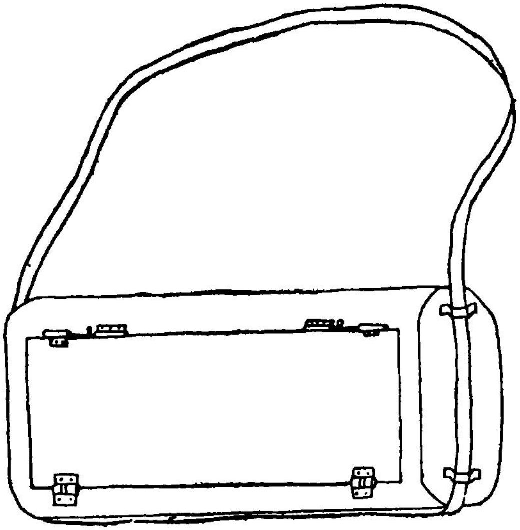

FIG. 61. VASCULUM (CLOSED).

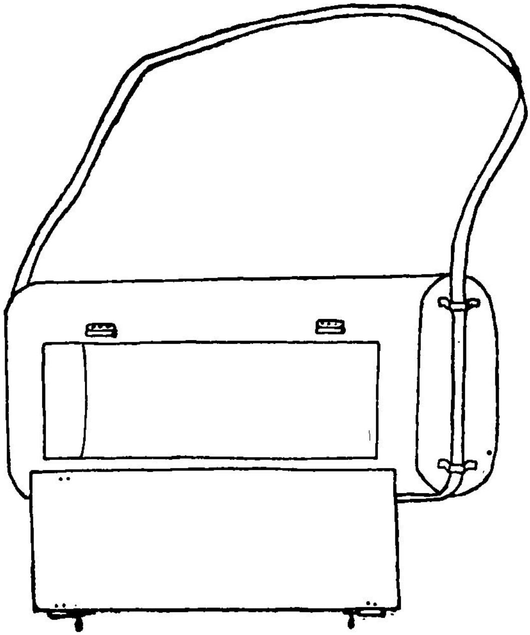

FIG. 62. VASCULUM (OPEN).

The vasculum (figures 61 and 62) is a japanned tin box, convex on both sides and capable of accommodating plants of the size of 17½" by 10½". It has an adjustable sling attached to the ends. One of its convex sides is hinged at the bottom so as to open outwards and downwards, thus serving as the lid. When closing, the lid is secured by a pair of wire latches at its top. Its dimensions vary with the size of the specimens to be collected, and with the collector's personal conveniences as well. If finances permit, it may be lined inside with thin asbestos sheet (about 1/16th inch thick). As it is not available ready-made in the market, it has to be made "to order" with the help of a tinker. The indispensability of a tin box of this type can be easily guessed. It serves as a very good receptacle for any kind, or all kinds, of specimens that are collected in the field.

The botanists' portfolio consists of two frames (of either wooden boards, or wooden laths, or pasteboard, or leather-board, or wire-laths) with a considerable number of blotting sheets between them (figure 63). The frames and the blotting sheets measure 18" by 12", and the former are held together, tightly pressing the blotting sheets, with the help of leather straps. The entire bundle is provided with a leather handle or a sling for carrying it about. Smaller or larger portfolios are also there, which are suitable for collecting any special type of plants. The portfolios are used for collecting plants for the herbarium. They begin the first preliminary treatment in the field itself. Other items are specially mentioned, if necessary, in the relevant portions of this text.

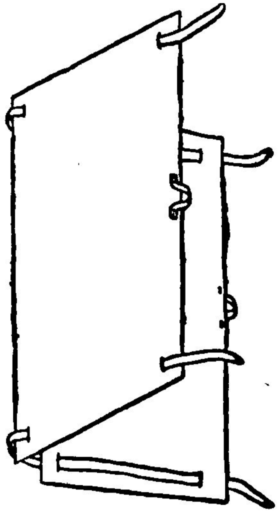

FIG. 63. PORTFOLIO.

Plants or their parts continue to live and grow for a long time even after they are collected from the field. Thus their structural features undergo some physiological changes which have to be arrested at once. Certain kinds of fungi grow on the organic matter and cause putrefaction; certain kinds of bacteria grow on it and cause decay; and insects also feed on it and damage it. Here comes the need for proper care and attention on the preservation and storage of plant specimens, which leads on immediately and directly to organization and maintenance of herbaria and botanical museums.

Thallophytes.—These include bacteria, fungi and algae. *Bacteria* are the primitive, unicellular, microscopic plants that cannot be seen without the aid of powerful microscopes. Prepared slides with the specimens of bacteria can be had from the biological firms, and exhibited with the help of microscopes which are fitted up with stages in the form of revolving drums. This will be rather a costly venture, since the microscopes have to be kept in special cabinets which should enable the necessary adjustments, and at the same time, ensure safety for the instruments—not to speak of the cost of the microscopes themselves. Where the necessary finances are wanting, the bacteria may be illustrated in charts which may be exhibited.

The *fungi* are also microscopic and are similar to the bacteria in being devoid of chlorophyll (the green colouring matter) and therefore incapable of manufacturing their own food. They grow parasitically on other living things, or saprophytically on dead and decaying organic matter. Many of the fungi put forth visible fructifications, but their spores are microscopic in size.

As for the microscopic forms, they may be best obtained in the form of prepared slides from the biological firms, and exhibited like the bacteria. Those with visible fructifications are carefully collected and preserved. If they are fungi with small fructifications, they should be collected with their substratum *in situ*. If they are intended for the herbarium (please see under Angiosperms) they are dried, with their substratum *in situ*, in the home-press. If large and woody or corky fructifications are to be preserved on the harbarium sheets, thin sections in a vertical radial plane may be taken of them (fructifications) and dried in the home-press as explained under herbarium-keeping.

The hard fructifications can be preserved entire by a process of slow drying and without the application of any pressure. For this, they are placed in a wooden or preferably glass container (in the form of a tray, cistern, jar or box) which is open at the top. The container with the specimens in it, is placed in the sun and covered over at the top with a glass plate. A small, narrow, gap is also provided for at the top when placing the glass cover. As the heat is absorbed more and more, more and more moisture is given out by the specimens, and the space inside the container becomes more

and more humid. The humidity arrests the rapid loss of moisture from the specimens, and consequently protects them against damage. In the afternoon, after the day has begun to be cooler, drops of water will be seen glistening from below the glass plate. As and when this occurs, the container and its glass plate are wiped dry. This process is repeated every day, until the amount of moisture that is given up by the specimens is reduced to nominal levels. Thereafter the drying may be stopped. The poison to be applied on these dried fructifications is prepared by dissolving 4 dr. of corrosive sublimate in 3 oz. of sulphuric ether, and then adding to it 2 oz. of turpentine and 3 oz. of alcohol. It should be applied immediately after it is prepared and in the way the herbarium specimens (of Angiosperms) are poisoned. The fructifications are then allowed to dry in the shade and under no pressure. They will also look best if they are given a double or triple coating of any spirit varnish at intervals of two days.

Large fructifications require no special mounts, while the smaller ones need glass-topped boxes. In the absence of any such box of suitable size, the inner sides of an open, wooden or thick cardboard box of sufficient depth, are given a lining of strips of paper of the same colour as that of the intended background. The specimen is fastened on to a thin cardboard, or a thick paper, of the chosen background colour. Pins should not be used for fastening it, because the metal would rust and spoil the specimen. The sheet with the specimen on it, is then pasted on the (inside) bottom of the box. The casing is closed with a glass plate of the size that is just sufficient to cover it without protrusions. The glass is held in place by strips of *passe partout* or of calico, pasted all round. The use of cellophane paper in place of glass, it may be stated here, is not advisable, as the cellophane does not last long.

Fleshy fructifications of fungi can be preserved in 5 per cent formalin or 75 per cent alcohol. A. 2·5 per cent solution of zinc sulphate in 1 per cent formalin, is recommended for preserving them with colour. The specimens have to be kept permanently in this solution. For more details of preservation in fluids, the pages under Angiosperms may be referred to (pages 93–98).

Algae are a group of primitive plants without the differentiation of the tissues distinctly into stem, leaves, roots, etc. They are mostly aquatic or marine, while some are also terrestrial but with preference for moist situations. The more primitive ones are microscopic, but the others are quite big enough. They are capable of manufacturing their own food materials and are not dependent on other living things for existence.

Museum illustration of the microscopic algae, may be arranged for in the same way as of the bacteria. The larger aglae, however, require different treatment when they are preserved for the herbarium or museum.

When algae are preserved for the herbarium, they are given a preliminary treatment before they are put in the press. The specimen concerned is placed in a basin of water (only sea-water should be used for marine algae or sea-weeds), and lightly agitated with a quil (or any similar instrument) so that the filaments float in the manner natural to them. A sheet of mounting paper of the size of the specimen, is then introduced under the alga. When everything is fairly spread out and settled, the paper with the specimen resting on it, is slowly and gradually withdrawn from the water, on to an inclined glass plate which is kept half-dipping into the water in the basin. The mounting paper with the specimen on it, is then covered over with a piece of muslin, or of slightly greased tissue paper and dried in the home-press as explained under herbarium-keeping. The mounting paper below the alga, and the latter's superimposed cover should never be separated or disturbed, from the specimen through the entire process of drying. By this means, most algae are made to adhere to the mounting paper below them. Thin flakes of mica are preferred to this paper, in the case of minute specimens. Melanospermous algae should be put into boiling water, until all the mucus is given out, before floating them on paper. The plants, after drying, may be treated as herbarium specimens (please see under herbarium-keeping).

So far as wet preservation is concerned, marine algae or sea-weeds are to be preserved in only 2 per cent solution of formaldehyde in sea-water. Certain types of algae, known as the Charales, have calcareous contents and should therefore be prserved only in 50 per cent solution of alcohol in water, formalin being injurious to them. Fresh-water algae may be preserved in 5 per cent solution of formaldehyde in fresh water. Green fresh-water algae can be preserved with colour by treating them with copper acetate. A 1 per cent solution of copper acetate in 2 per cent formalin is prepared. The alga is soaked in this solution for twenty-four hours, and then washed and preserved in 5 per cent formalin. For more details of preservation in fluids please see pages 93–98.

Sometimes the algae and the fungi enter into a partnership and form a biological combination, by which both these organisms are benefited. The combination is known as a lichen. The fungi store the necessary water for the algae which, in turn, prepare the food materials not only for themselves but also for the fungi. The lichens occur in various forms in almost all dry situations. Just as in the case of the algae and fungi. the lichens also have no leaves, stems, roots, etc.

Lichens should be collected with their substrata *in situ*. Immediately on collection, they should be pressed (if they admit of pressing) in the portfolio, with the substrata *in situ*, and then dried in the home-press (please see under herbarium-keeping). Lichens that do not admit of any pressure, are preserved and exhibited like the woody, fungal fructifications. The poison used, however, is only an 1·25 per cent solution of corrosive sublimate in alcohol.

Bryophytes—These include liverworts and mosses. Liverworts (*Hepaticae*) like fungi and algae, show little or no differentiation among their tissues into stems, roots, leaves, etc. They are flat and spreading in habit, and possess a little thickened tissue somewhat like the midrib of fleshy leaves. Liverworts are generally seen as flat, dark-green, mattress-like structures spreading even on bare rocks. They can tide over long periods of drought and high temparature, quite successfully.

Mosses (*Musci*) are closely allied to liverworts in the details of their life history. They are however endowed with a distinct upright stem and leaves, but they have no true roots. Their leaves are simple, stalkless, composed of a single layer of cells except at midrib, and arranged in three vertical rows.

When collecting liverworts and mosses for the herbarium (please see page 83), they should be subjected immediately to a moderate pressure in the portfolio. Even after they are placed in the homepress the pressure should remain only moderate.

Given a special treatment, the liverworts and mosses can be preserved with colour. Firstly, a saturated solution of copper acetate in glacial acetic acid is prepared. It is then diluted by adding four parts of water to every one part of the solution. The specimen, with a string tied to it at one end, is placed in this solution and heated nearly to the boiling point. Just when the solution begins to boil, the specimen is taken out by the string, and washed and preserved in 5 per cent formalin in the usual way. For more details on wet preservation please see pages 93–98.

Dry specimens of liverworts and mosses can be preserved and exhibited in glass-topped boxes as in the case of the hard fructifications of the fungi. The poison that is required to be used is only the 1·25 per cent alcoholic solution of corrosive sublimate.

Pteridophytes.—These include club mosses, horse-tails and ferns. Club-mosses (Lycopodiales), horse-tails (Equisetales) and ferns (Filicales) are green plants with fully developed tissue-differentiation. They have stems, roots and a great variety of leaf-forms, and an elaborate system of conducting vessels. They are, in fact, very highly evolved, non-flowering plants. The club-mosses have long stems with very short internodes which are densely covered by small leaves. Their spores are produced from, and borne on, the upper surface of the leaves. The spore-bearing leaves may remain like the sterile leaves in shape and size, or they may be specially modified and arranged to form cones. The horse-tails, too, have long stems, but they are rough with a coating of silica. The internodes are conspicuously long and the leaves are small, sheathing and scale-like. The spore-bearing (on upper surface, as in club-mosses) leaves are shield-shaped and arranged in the form of cones at the ends of shoots. The ferns hardly need any introduction, since they are so popular. Their stem generally remains within

the soil as a rhizome. The conspicuous aerial parts that are seen, are only the leaves. The leaves, when young, are generally kept coiled like a watch-spring. The leaf-veins generally branch in forks. The spores are borne either at the margins, or on the lower surface of the leaves. A few of these plants assume gigantic proportions and are mistaken for trees, unless minutely examined.

The club-mosses, horse-tails and ferns may be preserved on harbarium sheets as explained under Herbarium-keeping. The club-mosses and horse-tails can keep even better, if they are dipped in boiling water for two minutes and hung up in the air to dry, and subsequently poisoned with an 1·25 per cent solution of corrosive sublimate in alcohol. They may be mounted and displayed like the hard fructifications of fungi.

The club-mosses, horse-tails and ferns can be preserved *with* colour, if they are treated with copper acetate and glacial acetic acid, in the same way as for the liverworts and mosses.

Gymnosperms.— These are mostly trees, either tall or short, and bear naked or exposed ovules and pollen grains. Their ovules are borne along the margins and the pollen grains on the upper surfaces, of specially modified leaves. The seeds are also naked and are not encased in fruits. The Gymnosperms include such plants as the cycas and the pine.

For the herbarium, they can be pressed and dried, as explained under Herbarium-keeping.

Gymnosperm cones are woody and may be preserved dry like the hard fructifications of fungi. But the poison used, is only the 1·25 per cent alcoholic solution of corrosive sublimate. Gymnosperm leaves, if intended for wet preservation (please see pages 93–98), require to be immersed in boiling water for a couple of minutes, immediately after they are collected. Afterwards they may be preserved in 5 per cent formalin, but *not in alcohol* which is injurious to them. If the leaves are not treated in boiling water, they drop off soon.

The leaves of Gymnosperms can be preserved *with* colour, if they are treated with copper acetate and glacial acetic acid in the same way as for the liverworts and mosses.

Angiosperms — These are trees, shrubs or herbs and their seeds are contained in special structures, the fruits. The Angiosperms are further divided into the Monocotyledons and the Dicotyledons. For museum work, however, the Angiosperms may be artificially divided into herbaceous, aquatic, succulent, loose-jointed and glutinous plants. The herbaceous plants are recognized by their thin leaves, weak stem and small stature. The aquatic plants are those that grow in fresh-water, either floating at the surface, or half submerged, or at times, even fully submerged. Succulent plants are those which have thick fleshy and juicy leaves, or stems, or both. The loose-jointed plants possess caducous parts (i.e., parts which do not

hold on to the main body of the specimen for long). Glutinous plants stick to the paper between the folds of which they should be dried. Certain amount of experience (much time is not required to gain it) is required to spot out the loose-jointed plants and the glutinous plants from the rest.

Herbarium-keeping.—A collection of dried plants named and systematically arranged, is known as the *Harbarium* or *Hortus siccus.* Specimens collected for the herbarium, are brought home as quickly as possible and subjected to rapid extraction of the moisture in them, in order to preserve as much as possible, their natural colour and general appearance. During this process the plants are also subjected to a certain amount of pressure between several folds of driers (absorbent paper) just to obviate brittleness, and to prevent curling up, of their different parts. Only very simple equipments are required.

The driers may be good blotting papers or old newspapers, measuring 22½ inches by 17½ inches. They should be smooth and absorbent. They are arranged in batches of five sheets, each batch being folded across the centre to form a parcel, in such a manner that the fold runs parallel to the seventeen-inch side. The larger the number of driers per parcel, the better. If so desired, they may even be stitched together along the fold.

The pressure required is supplied in the *home-press* or *herbarium press* which, when intended for accommodating not more than two reams of driers, consists of a pair of what are known as *outside boards,* 8 *inside boards,* and a *few ventilators.* The *outside board* is a double board, measuring 18 inches by 11 inches by ½ inch or ¾ inch, and is formed by two boards closely glued together, and firmly secured by small screws at intervals of 3 inches along the edges, in such a way that the grain of one board crosses that of the other. The *inside board* is generally a wooden plank, 18 inches by 11 inches by 3/8 inch. A tin sheet may also be used in its stead. The ventilator (fig. 64) are slatted frames of wood, 18 inches by 12 inches. They are formed by nailing five straight wooden pieces, each measuring 18 inches by 1 inch by ¼ inch, parallel to and equidistant from each other, on six other wooden pieces, each measuring 12 inches by 1 inch by ¼ inch and forming cross-bars. The cross-bars also should be parallel to, and equidistant from each other. The frames, thus prepared, should not have any of the wooden pieces protruding out from the sides. High quality ventilators are made of aluminium rods, but they are costly. It is advantageous to possess at least a few ventilators, as they can also be used as outside boards during long collection trips.

With the materials described above, the press is built up as follows:—

Two parcels of driers are placed one over the other on one of the outside boards, and then the specimen is laid over them (parcels) in as natural a position as possible, without crumpling the

leaves and flowers. Both sides of the leaves and flowers must be displayed, if possible, while arranging the specimen. Specimens, too long for the paper, may be carefully folded; or, if this is not possible; they may be cut in two. For equalising pressure, and for keeping up the stability of the press, the specimens should be distributed about the drier, rather than confined to the centre. Parts of a specimen found overlapping other parts, should be separated from the latter by placing pieces of bibulous (absorbent) paper between them. This would prevent moulding and discolouration. For large and coarse plants, strips of pasteboard (stiff pad of several sheets of paper pasted together) or pieces of cotton batting (cotton prepared in sheets), should be placed about the sides. The large and cumbersome parts, such as tubers, corms, bulbs, etc., of the herbaceous plants, may be pared down, or their interior scooped out, before pressing. Aquatic plants and those collected in wet weather, should be wiped dry with a napkin, before they are placed in the press. Glutinous plants are sprinkled over with soapstone powder (" Talcum " face powder will also do), and then dried in the press. Succulent plants are first immersed in boiling water for a minute or two, but only up to the point from where the flowers arise. They are then allowed to drain on a cloth for a few minutes. Next, they are enclosed between two sheets of drying paper, and rolled over by a glass bottle (or any smooth roller) so as to gently crush, without completely flattening, the flowers and other parts that were not dipped in boiling water. They may afterwards be dried in the home-press. The soft fleshy portion inside such stout, succulent stems as in Cactus, etc., should be scooped out after scarring the exterior, and before pressing. Each specimen should be accompanied on the drier, by a number-slip giving reference to notes concerning the specimen.

Then another parcel of driers is placed over the specimen, so that its folded edge rests over the open edge of the parcel below it: and a pile is thus built up with alternating layers of specimens and parcels of driers (the bottom-most being a double parcel). The use of plenty of driers in proportion to the succulence of the specimens facilitates rapid absorption of moisture. A double parcel of driers is placed over the eleventh specimen; and, over this, is placed an is placed over the eleventh specimen; and, over this, is placed an inside board. Layers of driers and specimens are repeated above pile of driers, specimens and inside boards is formed to a height of not more than two feet. The inside boards serve the double purpose of securing uniform pressure for the specimens, and of giving stability to the press. On top of the pile, the other outside board is placed. It is advantageous to introduce a pair of ventilators at regular intervals into the pile, as they promote rapid drying.

They should be used in pairs with the cross-bars of one frame butting against those of the other. The entire pile is tied round with ropes or straps and then kept in the sun, preferably raised above the ground by means of a couple of dry objects like bricks,

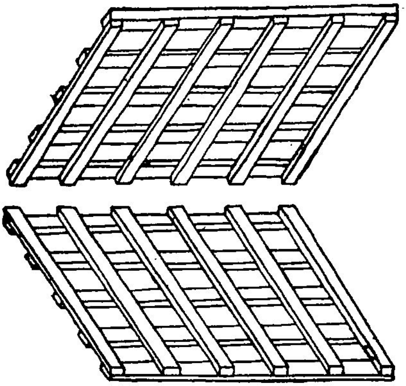

FIG. 64. A PAIR OF VENTILATORS FOR USE AS OUTSIDE BOARDS.

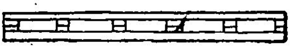

FIG. 65. A PAIR OF VENTILATORS FOR USE WHEN VENTILATING A HOME-PRESS.

stones, etc. A certain amount of weight is placed over the whole pile, which completes the formation of the home-press.

The weight used should be heavy enough to prevent wrinkling, without crushing the plant tissue. Different plants require different pressure. On an average, however, a weight of 60 lb. would suffice for most plants. If plants have thick stems, a sand-bag or two, of the size of a drier, may be used to equalize pressure.

The home-press formed as stated above, is known as the *weight-press*, because a weight is placed on top to obtain the required pressure. It will be called a *lever-press*, if the pressure is obtained from a lever mechanism; and a *screw-press*, if the outside boards are kept pressed towards each other by screws as in the case of the press for a tennis-racket. The term *wire-press* is used when frames of stiff, stout, galvanized iron wire form the outside boards. The wire-press can be used as a weight-press as well as a portfolio. Being a good conductor of heat, it accelerates drying.

There is no hard-and-fast rule fixing the length of the period of drying, which is dependent upon the nature of the specimens, and upon the quality and quantity of the driers used. The driers should be regularly renewed, the first change being within the first twelve hours of pressure. When changing the driers, the plants should be lifted with a pair of forceps only. Mistakes, if any, in

laying out the specimens on driers, are rectified during the first change of driers, as afterwards they become too brittle for alterations. The used papers which must have absorbed moisture, can be separately heated again in the sun and then put to use. The driers are changed when they are hot. Daily changes are necessary in the first few days (or the first week) and the subsequent changes are carried out on alternate days. A thoroughly dried specimen is recognized by its hay-like rattle, and by our not feeling it cold if placed against the cheek.

Most flowers retain their colour on herbarium sheets, if they are dried very rapidly, by enclosing them between driers and ironing them hot. Sufficient care must also be taken to see that they do not get charred.

After the specimens have thoroughly dried, they are poisoned with an 1·25 per cent solution of corrosive sublimate in alcohol. The poison is applied with the help of a soft brush without any metal fastening on it, or as an alternative the specimen itself may be dipped into the (same) solution kept in a glass cistern or tub. Any metal coming in contact with this poison, discolours it and (in consequence) the specimen as well. After the poison is applied, the herbarium specimens are again dried in the home-press for a day or two, but drying in the sun is not necessary.

The specimens may be kept indefinitely between the folds of driers, till they are required for an exchange transaction with any other institution, or for mounting on *herbarium sheets.*

The herbarium sheet is a firm, thick, white, writing cartridge paper of compact texture, measuring 17½ inches by 10½ inches and weighing about 28 lb. to a ream of 480 flat sheets. A drawing paper, fulfilling all these conditions, may also be used. It will be convenient to have sheets ready and printed at the bottom left corner as in the accompanying form. The botanical name of the plant is entered in a single line at the botton right corner. The regional name or names may be entered below it. The name of the family to which the specimen belongs, may be entered opposite the item " Remarks ", and other points below it.

Not more than one species should be mounted on one herbarium sheet. The specimen may be fastend to its sheet by means of a sewing thread which should go round, but not through, the different organs: or by means of bands of gummed paper. No metallic pins should be used, as they will rust and spoil the specimen.

They may also be permanently fastened to their sheets, with hot glue (of about the consistency of cream). For this purpose, the position which the plant should occupy on the herbarium sheet, is lightly marked out with a pencil. The specimen is laid, face downwards, on a sheet of newspaper, and the glue is applied over it with the help of a fine camel-hair brush. It is then lifted with a

MADRAS GOVERNMENT MUSEUM HERBARIUM

Col. No.________ Ref. No.________

Date________________

Col. by________________________________

Locality________________________________

Remarks________________________________

Fig. 66. A sample of the printed matter at the bottom left corner of the herbarium sheet of the Government Museum, Madras. The name of the plant is separately entered at the bottom right corner of the herbarium sheet.

pair of forceps, and laid in its position on the herbarium sheet. Thin straps of gummed paper may be pasted across the thicker parts of the specimen so as to prevent them from breaking loose whenever the herbarium sheet is accidentally bent. The excess glue is removed with a clean cloth, and the specimen with its sheet is subjected, overnight, to a slight pressure between the driers.

Herbarium specimens of one genus may be placed in a genus cover which is but a sheet of paper, 22½ inches by 17½ inches, and of the same quality as the herbarium sheet and folded breadthwise. The genus covers of one natural order may be grouped together between the folds of a brown paper. The latter groups may be arranged in the systematic order in a cabinet.

Care of the herbarium is a special task by itself, and calls for undivided attention. The specimens should be kept dry, free from dust, and not too overcrowded. Naphthalene, camphor, or any strong-scented oil keeps out the herbarium pests to a certain extent; but safety lies only in periodically poisoning the specimens,

in addition to renewing those volatile insecticides. They should be frequently examined, and, if the slightest trace of mould, or of moisture, is seen even on one specimen, the entire collection should be re-poisoned.

Insect depredations can be reduced, if the specimens with their sheets are periodically fumigated in an air-tight tin box, by saturating the space inside, with the vapour of carbon bisulphide. A mixture of three parts of Ethylene dichloride and one part of Carbon tetrachloride is recommended as a safer fumigant. If these two chlorides are not available, large quantities of paradichlorobenzene may be used.

Mounted herbarium specimens, if selected for exhibition, should be protected against exposure to dust; for which, it is better to keep all the specimens covered with glass. The herbarium sheet with the specimen, is pasted on a glass sheet cut to the required size. Long narrow strips of glass are pasted one over the other along the four edges of the herbarium sheet to a uniform height of the maximum thickness of the specimen. Another glass sheet of the same dimensions as those of the one placed at the bottom, is now pasted firmly over the glass strips. Gum arabic, dissolved to the required consistency in 1 per cent aqueous solution of corrosive sublimate, can be used for pasting these materials. The joints of the glasses are all sprayed or painted over with a thin 1 per cent solution of celluloid in a mixture of equal parts of acetone and amyl acetate. The specimen thus gets encased in glass. The irregularities at the sides may be neatly covered up with *passe partout*, or with calico. The casing may also be provided with a strut (or two, if necessary) at the back, using glass bits and calico.

Flowers, etc.—Flowers, pitchers, etc., of the Angiosperms will lose their shape if treated in the home-press. They get flattened out and become unseemly, although they continue to retain their structural details. They satisfy the scholar alright but not the other classes of people. Such specimens are generally preserved, therefore, in fluids. When the cost and inconvenience of handling the material are to be avoided, the following method is recommended but only with some reservations. The given specimen is packed in a tin of fine, warm (preferably cedar-wood) sawdust and heated over an oven. While packing it, care should be taken to see that all possible hollows in the specimen are also filled so that the pressure applied is equal both inside and outside the specimen. This ensures the object against shrinkage and collapse. Within the tin, the specimen should occupy a position in the centre, but not near the bottom, nor the sides nor the surface. With the help of suitable clamps, a centigrade thermometer is inserted into the sawdust and so held that its bulb is close to the bottommost part of the specimen, for recording the temperature near the flower. As the heating proceeds, the tin gets heated up very quickly, but the heat takes a long time to come up through the sawdust which is a bad conductor

of heat. In the meanwhile so much of heat accumulates at the bottom of the tin, that even if the heating is stopped, the accumulated heat still keeps coming up through the sawdust. The specimen inside the sawdust thus runs the risk of getting charred. The safer procedure will therefore be to heat the tin for a short while till the mercury begins to move a little, and then to stop heating. The moment the thermometer records 60°C, the specimen should be taken out and the whole process repeated with another tin of sawdust. There is no specification regarding the optimum temperature and the period for drying. These factors vary with individual specimens, but there is a generalized recommendation of a temperature of about 45°C lasting for about 10 minutes. The temperature can be maintained constant, by stopping or introducing the heat at the bottom of the tin. If, however, a heating device provided with a temperature-regulator can be had, it will be very useful for work of this kind. After the drying is satisfactorily completed, the specimen is taken out, and the particles of sawdust, if found adhering to it, are brushed off with a camel-hair brush. The specimen may afterwards be given a thin protective coating of paper varnish.

Dry fruits, etc.—Such hard objects as dry fruits, barks, seeds, etc., may be preserved and mounted as indicated for hard fructifications of fungi, but with this difference that the poison required is only an 1·25 per cent solution of corrosive sublimate in alcohol.

Timber.—Timber specimens, however, present a problem of their own. The reduction of moisture in timber, known as *seasoning*, gives the material its durability, strength, stability, lightness and ability to get well-polished and to take in preservatives (if required). All these useful effects of seasoning overshadow the harmful one, namely, rendering the wood combustible. Also, timber is capable of absorption of moisture in the atmosphere, and of parting with the same when dry conditions return. The rate of drying of timber is much faster at the surface than at the interior. This property causes it to warp or split, when drying. Several months are required for drying timber, the period varying with the thickness of the material. In view of the importance of wood in trade and commerce, new and improved methods of seasoning are devised every day by research institutes. As far as museum specimens are concerned, any easy laboratory method can be devised successfully, provided the temperature of the specimen is raised gradually (not above 75°C) and provided the rate of evaporation at the surface is made to keep pace with that in the interior. These conditions are achieved by gradually increasing the temperature of the specimen, as well as the humidity of the surrounding air, to the required levels.

The temperature and the period required for drying are different for different types of timber. On an average, however, a maximum of 70°C appears to be within safe limits for most

timbers. The heating should last till the specimen has dried to the required extent. This can be felt by the weight and warmth of the material. To the experienced eye, the colour also serves as an indicator in most cases.

Hand specimens of timber can be seasoned in an almost closed container. A glass jar is filled to about a tenth of its capacity with water. Samples of timber are put into the jar with plenty of air-spaces among them, and its mouth is so covered with a glass plate as to leave but a very small gap. The smaller this gap the better the result. The jar is then placed in an air-bath, and gradually warmed up to the required temperature. Thus heated, water in the jar gets vaporised; but quick escape of its vapour is effectively checked by the minuteness of the opening at the top. This results in the increase of humidity inside the jar, which helps to equalize rates of evaporation of moisture from the surface, and from the centre, of the specimens. They may be periodically examined for splitting, warping, etc. This method of heating should be continued for a few weeks after the entire quantity of water in the jar has evaporated. The whole process may take some months for completion.

In case an air-bath is not available, a number of timber specimens may be piled up in a regular order, with plenty of room for free circulation of air between them, and the pile may be exposed to warm dry air for a number of months. It is absolutely necessary that the pile should be protected from damp and cold.

There is certainly no objection to procuring already-seasoned specimens of timber from the market, *provided* reliable information can be obtained concerning the name of the plants, locality, etc. Such specimens would indeed go a long way to lessen the task, but the authenticity of the information furnished by traders is always questionable. They may not be able to give out the correct details, either because of their ignorance, or because of their fear of competition.

If the timber specimens are intended either for storage or for exhibition, and if they are not likely to be frequently handled about, they may be coated with two or three layers of varnish, after seasoning. Varnish severs their contact with the moisture in the atmosphere, and thus offers adequate protection for most specimens from fungi and insects. This protection will however be lost if the specimens are frequently handled, or if they are allowed to be freely crawled upon by insects.

There are also certain kinds of timber, which are readily susceptible to decay and insect attacks. Such specimens may be kept immersed, with the help of sinkers, for a few months in 2 per cent solution of corrosive sublimate in 20 per cent formalin, before they are seasoned. The treatment leaves deposits of the sublimate inside the wood, which keep out the fungi and insects to a considerable extent.

If it is desired to render the timber spe.imens fire proofs, they may be kept immersed (with the help of a sinker) for two or three months in a solution of Ammonium phosphate, and then seasoned.

Timber specimens with holes should be fumigated in an air-tight tin box, as explained under *herbarium keeping*. The holes may later on be filled with molten paraffin wax, with the help of any convenient spoon. If it is desired that the holes should remain as such, fumigation should be carried out periodically.

It is better to preserve timber specimens with the bark intact, using if necessary, glue or poisoned gum arabic.

For exhibition purposes, specimens of timber should show as much of the structural details as possible. A single specimen can be cut, for instance, into a six-sided block. One of the sides should remain with the bark. Its opposite side should represent the tangential section (the section taken at right angles to the radius of the stem). Of the remaining four sides, one should represent the radial section (taken through the centre of the stem). Its opposite side will invariably represent a tangential section, or a portion thereof. Both the fifth and the sixth sides will consequently turn out to represent the cross-section of the timber (Figure 67).

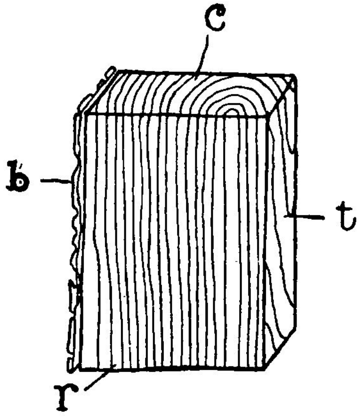

FIG. 67. SHAPE SUGGESTED FOR TIMBER EXHIBITS (A).
b. BARK ; *c*. CROSS-SECTION ; *r*. RADIAL SECTION ; AND *t*. TANGENTIAL SECTION.

A timber specimen may also be shaped into another form (Figure 68) if it be a small log with the bark intact. Using the stouter end as the base, the specimen is cut horizontally at the middle and at right angles to the longer axis. The cut should not cross the pith, and should stop when it coincides with any one diameter of the log. The specimen is then cut from the top vertically downwards along the diameter which should be in the same line as the one at which the horizontal cut stopped. When both

these cuts meet, a small block comes off and may be stored as a duplicate specimen. The parent piece will show out the details of the radial, longtitudinal and cross sections (Figure 68).

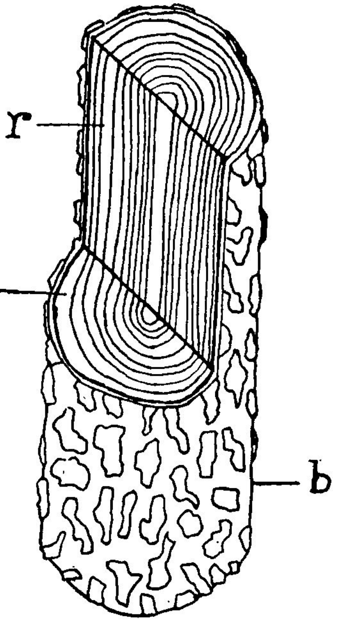

FIG. 68. SHAPE SUGGESTED FOR TIMBER EXHIBITS (B).
b. BARK; c. CROSS-SECTION; AND r. RADIAL SECTION.

A little more complicated but improved form for a timber specimen can be attempted with a little experience and patience, as in Figure 69.

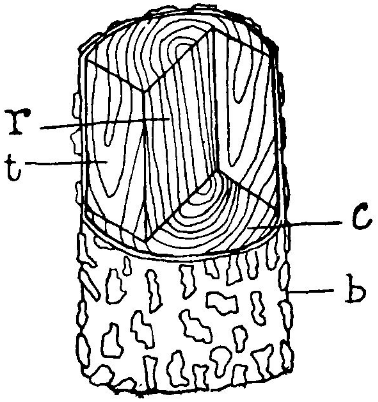

FIG. 69. SHAPE SUGGESTED FOR TIMBER EXHIBIT (C).
b. BARK; c. CROSS-SECTION; AND t. TANGENTIAL SECTION.

Leaf-skeletons.—Leaf-skeletons, properly extracted and mounted will greatly benefit the learners.

A known quantity of 30 per cent solution of sodium carbonate (chemically pure washing soda) in water, is heated in a glass vessel. When the liquid begins to boil, the heating is stopped, and after the boiling has ceased, 7 grams of calcium hydrate (anhydrous calcium hydroxide) are dropped into every 50 c.c. of the liquid. The solution is then allowed to cool down, and filtered. The leaf chosen, is boiled in the clear filtrate in a glass vessel till the colour of the solution becomes very dark. In the initial stages, the leaf may keep floating on the surface, in which case, it should be repeatedly thrust into the liquid, by means of a glass rod with a smooth, rounded end which may not injure the specimen. The bulb-end of a broken thermometer can be used for this purpose. When the solution becomes dark in colour, the leaf is taken out and placed in a petri dish. Its surface is gently rubbed several times, with cotton swabs, to see if the soft tissue could be easily removed. The leaf should not be rubbed with fingers, as the liquid in which it is boiled is caustic. If the soft tissue is not easily removable, the leaf should be boiled again and tried. The whole procedure should be repeated again and again, till all the soft tissue comes off with ease from both the surfaces of the leaf. While rubbing the soft tissues off, the leaf should not be allowed to get dry; it should be frequently moistened with the solution in which it is boiled. The skeleton, thus extracted, is dried between sheets of glass, and mounted dry.

Fluid-preservation.—Soft parts of plants are best preserved in fluids only, if they should retain their shape without suffering any shrinkage. In order to arrest as quickly as possible the physiological changes (page 78) within the specimen, the material is first exposed to the action of a stronger fluid, and then transferred to a weaker one. The latter fluid serves to wash out the lingering action of the first, and is therefore generally referred to as the washing fluid, as opposed to the killing fluid which is used first. If allowed to remain far too long in the killing fluid, the plant material gets damaged. Hence the need for washing off the killing fluid. It is advisable to keep the specimen for a number of days in the washing fluid which not only dilutes the traces of the killing fluid, but also collects and dissolves the waste matter that precipitates down from the specimen. After a prolonged period of washing that may extend over a few weeks and after the waste matter has ceased to precipitate, the washing agent is discarded and the specimen is transferred to a third solution which may be appropriately termed the *preserving agent* or *the preservative*. If the treatment in the washing agent has not been thorough, the preservative will get stained in course of time, in which case it has only to be used as a second washing agent. For this purpose, and for the purposes of certain scientific requirements, it is most desirable that the washing agent and the preservative are of the same chemical composition.

Of the several fluids in use, formalin and alcohol are the most extensively used for killing and preserving plant parts, although their colour is lost unless some special treatment is given to them. A few formulae for their dilution will be found very useful.

Y per cent solution can be obtained from a c.c. of an X per cent one, by adding $a\left(\frac{x-y}{y}\right)$ c. c. of water. Numerically, a 10 per cent solution can be obtained from 20 c.c. of a 40 per cent one. by adding $20\left(\frac{40-10}{10}\right)$ or 60 c.c. of water.

A copy of the following table for the dilution of alcohol may be kept on a card, for easy reference whenever required. The desired dilution is obtained by adding to every hundred cubic centimetres of alcohol of the given strength, so many cubic centimetres of water as represented by the figure in the table, shown *below* the dilution given and *against* the dilution desired.

TABLE.

Table for diluting alcohol.

Dilution desired.	*Dilution given.*									
		90 PER CENT.	85 PER CENT.	80 PER CENT.	75 PER CENT.	70 PER CENT.	65 PER CENT.	60 PER CENT.	55 PER CENT.	50 PER CENT.
85	..	6·6	..	..	..	..	..	..	..	..
80	..	13·8	6·8	..	..	..	..	..	..	..
75	..	21·9	14·5	7·2	..	..	..	..	..	..
70	..	31·1	23·1	15·1	7·6	..	..	..	..	..
65	..	41·5	33·0	24·7	16·4	8·2	..	..	..	..
60	..	53·7	44·5	35·4	26·5	17·6	8·8	..	..	..
55	..	67·9	57·9	48·1	38·3	28·6	19·0	9·5	..	..
50	..	84·7	73·9	63·0	52·4	41·7	31·3	20·5	10·4	..
45	..	105·3	93·3	81·4	69·5	57·8	46·1	34·5	22·9	11·4
40	..	130·8	117·3	104·0	90·8	77·6	64·5	51·4	38·5	25·6
35	..	163·3	148·0	132·9	117·8	102·8	87·9	73·1	58·3	43·6
30	..	206·2	188·6	171·1	153·6	136·4	118·9	101·7	84·5	67·5
25	..	266·1	245·2	224·3	203·5	182·8	162·2	141·7	121·2	100·7
20	..	355·8	329·8	3[illegible]4·[illegible]	278·3	25[illegible]	2[illegible]7·[illegible]	201·4	176·0	15[illegible]·6
15	..	505·3	471·0	436·9	402·8	368·8	334·9	301·1	267·3	233·5
10	..	801·5	753·7	702·9	652·2	601·6	551·1	500·6	450·2	399·9

According to another method, if it is required to get a c.c. of b per cent solution from an a per cent one, $(a-b)$ c.c. of water should be added to b. c.c. of a per cent solution. Expressing it numerically, to prepare 75 c.c. of 60 per cent solution from one of 75 per cent (75–60, or) 15 c.c. of water should be added to 60 c.c. of the 75 per cent solution.

The commercial formalin sold in the bazaar is (unless specifically indicated to the contrary), a 40 per cent solution of formaldehyde in water. A 10 per cent solution is recommended as the killing agent in most cases, and 5 per cent solution as the washing agent and preservative. Of the various types of alcohol, only ethyl alcohol is referred to in these pages. It is not necessary to buy the " absolute " ethyl alcohol which is costly; ethyl alcohol, sold as rectified spirit which is generally 94–96 per cent strong,

may be used. When the strength is not indicated, it is safer to assume that it is 95 per cent strong. The rectified spirit is recommended for use as the killing agent, while a 75 per cent solution serves as the washing agent and preservative.

When a particular plant material is known to contain substances which are soluble in water, it is killed, washed and preserved in alcohol, but if it is known to contain substances which are soluble in alcohol, it is killed, washed and preserved in formalin. If the substances in the specimen are soluble in neither formalin nor alcohol, the choice of the fluid is decided by the probable treatment that will be given to the specimen on some future day. If information on this too is wanting, then the cheaper of the two fluids (viz., formalin) is used. Difficulties will arise if the substances contained in a specimen, are soluble in formalin as well as in alcohol. In such cases, special solutions are tried. A word of caution is necessary, when dealing with specimens containing calcareous (calcium carbonate) materials. These substances are not soluble in formalin as such, and may be preserved successfully in formalin, but for short periods only. Formalin in course of time, slowly changes into formic acid and water. The acid part reacts on calcareous matter. For preserving such specimens, therefore, only alcohol should be used. In this context it goes without saying, that when specimens are to be preserved for indefinitely long periods, and when funds permit, alcohol is the medium to be preferred provided it does not harm the specimens.

Fleshy fruits should be preserved in Hessler's fluid only. This fluid is obtained by first preparing a 5 per cent solution of zinc chloride in water, and then adding to every 40 c.c. of the solution, 1 c.c. glycerine and 1 c.c. of 40 per cent formalin. When preparing the zinc chloride solution, some heat may be produced; in which case the liquid should be allowed to cool down. If a precipitate appears on cooling, the clear solution at the top should be filtered or decanted off, and then glycerine and formalin added to the clear filtrate. The fruits are dropped into the fluid, and kept immersed with the help of any small weight such as a glass stopper. They may take a few weeks to absorb the solution and sink by themselves, by which time the liquid will also get deeply stained. The specimens may then be transferred to, and preserved in, freshly prepared Hessler's fluid.

Green Angiosperms can be preserved *with* colour, if they are treated with copper acetate and glacial acetic acid in the same way as for the liverworts and mosses.

But the following treatment gives better results : The commercial formalin is diluted to 10 per cent strength by adding water. Hard, blue crystals of copper sulphate are then dropped into it little by little, stirring the solution in the meanwhile with a glass rod, till no more crystals get dissolved. Heating the solution for hastening the process, should be avoided lest the formaldehyde gas

should get lost. The solution is then recanted. The chosen specimen is kept immersed in the filtrate for a week and then transferred to a colourless, 5 per cent aqueous solution of formalin (freshly-prepared, but without copper sulphate) which acts as the washing fluid (page 93), and gets discoloured. Whenever the discolouration appears, the 5 per cent strong fluid is renewed, until there is no more discolouration. The specimen can then be preserved *with colour* in a colourless, 5 per cent aqueous solution of formalin permanently.

Plants containing red-brown and green colours can be preserved with colour, if they are treated as follows. They should be kept in an 1 per cent solution of sodium bisulphite in water. Citric acid is then added to the solution, little by little, till a strong odour of sulphur dioxide is given off. The specimens are next *washed* and *preserved* in 4 per cent formalin. By this treatment the red-brown and green colours are retained, though not entirely.

Wet specimens require no special supports for display, if they comfortably fit into the jars. But when the jar is too big, or when the specimen is too small to keep itself erect, it should be fastened to a transparent support, with the different organs spread out in the very manner intended for display. A thin glass plate with edges ground, or (preferably) mica, is so cut that its breadth is about 0·4 inches shorter than the internal length or the diameter, as the case may be, of the jar. Also, it is better to have it about 0·2 inches longer than the depth of the vessel. A fine, strong thread serves as the fastening medium, passing through only such parts of the specimen as are expected to be close to the support. When glass is used the two ends of the string are knotted at the back. There may be one or more such fastenings of strings, and in the latter case, the strings and the fastenings should run horizontal and parallel to each other. If mica is used as the support, the parts of the specimen expected to be in contact with it, are stitched to it, and so adjusted as to get the knots on the other side of the mica. The whiskers of the knots are trimmed off with a pair of scissors. For neat display, therefore, mica is more helpful than glass, but the choice is governed by the weight of the specimen and the funds available. The dimensions given above for the support, need not be rigidly adhered to. They should be so varied as to suit the size of the specimen concerned. The background is provided by painting the back of the jar, externally, with an oil colour. Or a glazed white paper, or any coloured paper (if a colour other than white is required, and if the colour of the paper is fast enough), may also be profitably used, wherever possible. It is placed inside the jar, closely pressed against the back, and kept in place by its own stiffness; or it may be fastened to the support on which the specimen is mounted.

The jars of specimens, preserved wet, should be properly sealed, before they are exhibited or stored. If the jar is supplied with a lid fitting into it, it is closed, and with a convenient brush, a coating or two of molten paraffin wax, the melting point of which is

at least 60° C, is applied over the edges of the lid, after doubly making sure that the lid and the rim of the jar are perfectly dry. The irregularities of the paraffin layer can be trimmed off with an used safety-razor blade.

If the jar has no lid of its own, a circular wall of plasticine is built up from an inch below the rim (Figures 70 and 71) and to the height of 2 inches. There should be at least 0·3 inch of gap all round between the plasticine wall and the jar, except at the place of attachment which, as already stated, should be an inch below the rim. The cup of plasticine which is thus built up round the mouth of the jar, should be able to hold any thin liquid, without leakage. The jar is now covered with a glass disc, shorter than the outer circumference of the rim, but bigger than the inner diameter of the mouth of the jar. Keeping all the external glass surface perfectly dry (near the mouth of the jar) molten paraffin wax (the melting

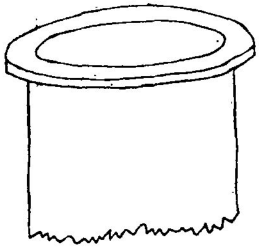

FIG. 70. TOP PORTION OF A SPECIMEN JAR, READY FOR SEALING WITH PARAFFIN WAX.

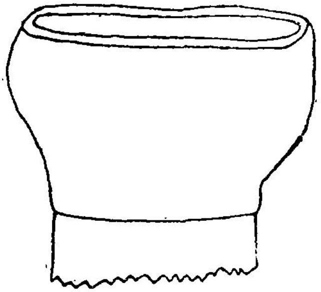

FIG. 71. A CIRCULAR WALL OF PLASTICINE, BUILT ROUND THE MOUTH OF THE SPECIMEN JAR FOR SEALING IT WITH PARAFFIN WAX,

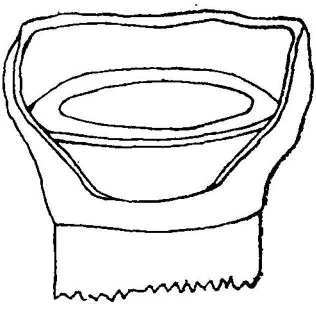

FIG. 72 A PART OF THE PLASTICINE (SHOWN IN FIG. 71), CUT OUT.

point of which is not lower than 60°C), when about to solidify is gently poured over the glass disc. During this process, the glass disc should not move, nor should any air-bubble get in. For this, the paraffin should be poured slowly, but fast enough not to give it time to solidify before filling up the cup of plasticine. The paraffin is allowed to solidify; the plasticine is removed; and the wax is trimmed as required, with a penknife (Figures 73 and 74). It may be allowed to stand as it is, or if desired, painted over with any oil colour.

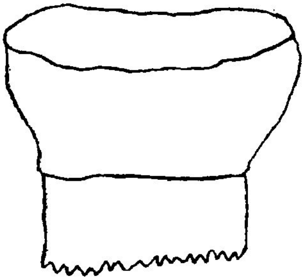

FIG. 73. TOP PORTION OF A SPECIMEN JAR, AFTER THE PARAFFIN WAX HAS SOLIDIFIED, AND AFTER THE PLASTICINE HAS BEEN REMOVED.

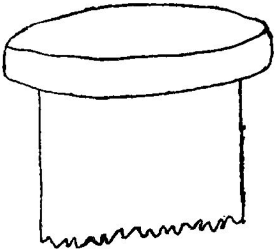

FIG. 74. TOP PORTION OF THE SPECIMEN JAR, AFTER THE PARAFFIN WAX HAS BEEN TRIMMED.

If funds permit, formalin jars can be given an excellent finish, if they are sealed with Stockholm tar and red lead. The black mobile tar is kept stirred in a cistern, and more and more red lead is added to it (in small quantities each time) till the mixture puts on a chocolate colour and a thick pasty consistency. The mouth of the jar is closed with a glass disc of the size mentioned in the preceding paragraph, and the disc is kept lightly pressed down with the left fore-finger. The chocolate-coloured paste is then applied over, and along, the edges, using an old penknife for the purpose. Excess of the paste, if any, and its irregularities can be scraped off, after it has dried. This method of sealing is not recommended for *jars containing alcohol.*

The best sealing cement would give way, if repeatedly brought in contact with the preservative. Frequent handling of the jars should therefore be avoided.

If, for any reason, the jars are not satisfactorily sealed, the specimens have to be examined frequently, to note if the preserving fluid has evaporated away leaving the specimen or a portion of it exposed, in which case, the loss from evaporation has to be made good. It is better to have the entire fluid renewed. The evaporation, however, is effectively checked if the jar is sealed with paraffin wax.

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SECTION III.

Minerals, Rocks, Fossils, Etc.—Collection and Preservation.

By M. S. CHANDRASEKHAR, B.Sc., F.B.S.,

(Curator, Botany and Geology Sections, Government Museum, Madras.)

Introduction.—A collection of local rocks, minerals and fossils will go a long way to drive home to the students accurate ideas of these important objects of study. The value of charts, maps, etc., as teaching aids is surpassed by that of relief models. An attempt is made here to give an account of the methods of preparing these models, and of collection, preservation, etc., of rocks, minerals and fossils.

Minerals.—Minerals can be looked for at mines, quarries, excavations, railway and river cuttings and exposed masses of rocks. They may be collected in sextuplicates, if abundantly available. One specimen may be reserved for exhibition in the museum, and two for study and identification. The remaining three specimens may be stored for renewing the exhibit if necessary, or for collecting more minerals by exchange.

Most minerals keep well if they are protected from dust. Fine, transparent crystals of sulphur and other thermosensitive minerals should not be exposed to bright sunlight, as they crack, sometimes with explosion, even by the warmth of our hands.

Preservation of minerals which easily change, presents a difficult problem to their custodians. Deliquescent minerals (those which take up atmospheric moisture and dissolve in it), and efflorescent minerals (those which lose water of crystallization and become powder), should be kept dry in air-tight containers, the air inside being dehydrated by quicklime in the case of the former minerals. A glass jar of a convenient size can be used, provided it is strong, non-leaky and free from cracks. The mouth of the jar should be closed with a glass plate and celluloid paste (made of waste celluloid strips and acetone). A thin coating of paraffin wax along the joint, will complete the work. Should there be any difficulty in procuring such a container to suit the specimen, one can be improvised as follows :—

A thick rectangular slab with a central elevated platform on it, is prepared in clay and cast in plaster of Paris. The area of the elevated platform should suit the size of the specimen. The position which the mineral should take up, is lightly marked out on this platform. Around this marking, small linear trenches are

made at convenient distances from each other. Glass bits, much smaller than the size of the mineral concerned, are firmly fixed into these trenches with a little plaster, so that only very little of them is exposed. They thus form a sort of a fence for the mineral. Next, four trenches are made near and along the outer four edges of the plaster slab, and four glass plates are fixed into these trenches, forming the walls of the future air-tight container. These glass plates should just touch each other laterally, without overlapping, nor with appreciable gaps between them. The plaster slab and the corners formed by the glass walls, are all heavily coated several times with a 5 per cent solution of poly-vinyl acetate in a mixture of equal parts of toluene and acetone. The mineral is placed on the central platform, and is prevented from slipping out by the fence of small glass bits. Another glass plate is then placed on top of the whole mount, so that its edges just rest on the glass walls of the container without projecting out nor leaving appreciable gaps. The edges are then sealed with celluloid paste. After the paste has dried, the plaster and all the joints of the glass plates are heavily coated on the exterior with 5 per cent solution of poly-vinyl acetate. The casing which is thus constructed is both air-tight and water-proof.

It is recommended that pryrite and marcasite (the two iron sulphides which become disrupted in damp air into iron sulphate and sulphuric acid that may affect the neighbouring minerals too), should be washed first in ammonia and then in absolute (ethyl) alcohol. They should be dried at 70°C and may afterwards be given a coating of one or two thin layers of 5 per cent solution of poly-vinyl acetate.

Some authors recommend wrapping minerals closely with cellophane paper. The writer is opposed not only to this mode of preservation, but also to coating a specimen with chemicals. Either method will obliterate the lustre and texture of the mineral or sometimes even alter the colour, thus destroying the purpose of exhibition.

A good plan will be to restrict these treatments to the duplicate minerals only, so that, if the specimens on exhibition get affected by exposure to air, the duplicates may be stripped of their preservative coat and exhibited. The preservative treatments, however, *have* to be given to very rare minerals which cannot be easily procured, even if they be under exhibition.

As a rule, a minerological crystal should not be broken out of its rock: it should be exhibited as such. Powdery minerals, like monazite, sand, etc., may be exhibited in glass-topped boxes, the making of which has already been described at page 79.

Not only the name and locality, but also the chemical composition (when it is known) should be stated on the labels of minerals,

Rocks.—When collecting rocks, those of convenient size may be chosen. They should be neatly trimmed in the field itself by breaking out the projecting parts with a geologist's hammer. This hammer is of hard steel that does not easily chip on the edges when it is used for breaking rocks. It has a rectangular face with sharp edges at one end, and a chisel at right angles to the handle, at the other end. It may be japanned to prevent rusting, and fastened to the handle by a screw-wedge. The actual process of trimming, however, requires practice. While trimming, a portion of the outer weathered surface should be retained intact.

Rocks, in general, need no other special care than adequate protection from dust and abrasion. Samples of soils may be exhibited in glass-topped boxes. How to make such boxes has already been described on page 79.

It is desirable that the label mentions also the constituent minerals, in addition to the name and locality of the specimen. In the case of soils, the label should include, if possible, also the results of their physical analysis.

Fossils.—Fossils may be looked for on weathered surfaces of compact limestones, abandoned quarries, exposed sections of earth, nodules, concretions and ploughed fields. Even apparently unfossiliferous limestones and clays may also be microscopically examined, for the remains of micro-organisms. When collecting fossils, those from one stratum of earth should not get mixed up with others from another stratum. They should be packed separately, then and there, at the time of collection.

Fossils should be collected with the matrix intact. In general they do not require any treatment in the field. Fossil leaves in particular, should not be given any protective coating since it damages them. Small friable fossils, however, may be strengthened with a thin coating of gum arabic. Fossil impressions on wet clay, shale, etc., should be dried only slowly as, otherwise, the material will crack. The dried material may be cleaned with a soft brush and hardened therefater, with a solution of shellac in methylated spirit. Specimens of fossil wood may be hardened with a coating of paraffin wax.

Large friable fossils crumble to pieces on drying, and should therefore be carefully handled. They should be first wrapped in paper, and then covered up with a moderately thick layer of plaster of Paris. If they are not hard enough, they may, before wrapping in paper, be given a coating of glue, or a thin solution of gelatine in warm water, or a thin solution of shellac in methylated spirit. The paper serves only to prevent the plaster from adhering to the specimen. Wooden splinters or thin iron rods, if tied to the plaster, would serve as additional supports in transit.

Moderately delicate bone fossils may be wrapped in linen or calico, and covered up with a thick layer of corn-flour paste, or paraffin wax. When a fossil skeleton has to be taken out in pieces from the site, a rough sketch of the same *in situ* has to be drawn. Each piece that is taken out should be marked with a number which should correspond with those on the adjoining piece and on the rough sketch.

Small fossils, embedded in a loose matrix of earth, can be easily cleaned by breaking up and washing it inside a beaker of water. The fossils that separate and float at the top can then be easily collected. If however, their matrix is hard, they are soaked for a day in a solution of Potassium hydroxide, before washing in a beaker of water. Dirty and coloured corals may be washed with soap and water.

Large fossils, embedded in a loose matrix, may be washed with water which should afterwards be filtered through a series of sieves of diminishing mesh, so that no microscopic fossil can be lost. If, however, their matrix is hard, it should be chipped off using only a gentle force and keeping the material on sand.

Fossils, after cleaning, should be kept dry. A solution of Canada balsam in Xylol serves as a useful varnish for any fossil. When a coating of any preservative is applied, the matrix (if it is not removed from the specimen, should also be treated with it. Fossils with traces of marcasite and pyrite should be dehydrated thoroughly by washing in absolute (ethyl) alcohol, and drying at 70°C. They are then given a coating of a thin solution of Canada balsam in Xylol or of Cellulose acetate in acetone. In their stead molten paraffin wax may also be applied in thin layers, but it will be a poor substitute. These fossils, though treated with preservatives, should be kept in air-tight containers. An account of such containers has already been given at pages 100–101.

Large broken pieces of a fossil can be stuck to each other with plaster of Paris. Smaller ones would require a paste of celluloid in acetone for cementing. Small fossils, when intended for exhibition, may be mounted on plaster pedestals. For this, the lowest part of the specimen is slightly inserted into the plaster before the latter begins to set.

The label should contain the family name, the name of the specimen, its geological age and its locality.

Geological Models.—Because of their ability to present subjects in terms of three dimensions, models should take the place of charts, wherever possible.

Relief models are expensive and generally not accurate. Simple models of geological features, such as faults, folds, etc., can however be made of wood, or plaster of Paris, or even cardboard. They will generally be in the form of six-sided blocks with the sides and the top painted over in the required manner.

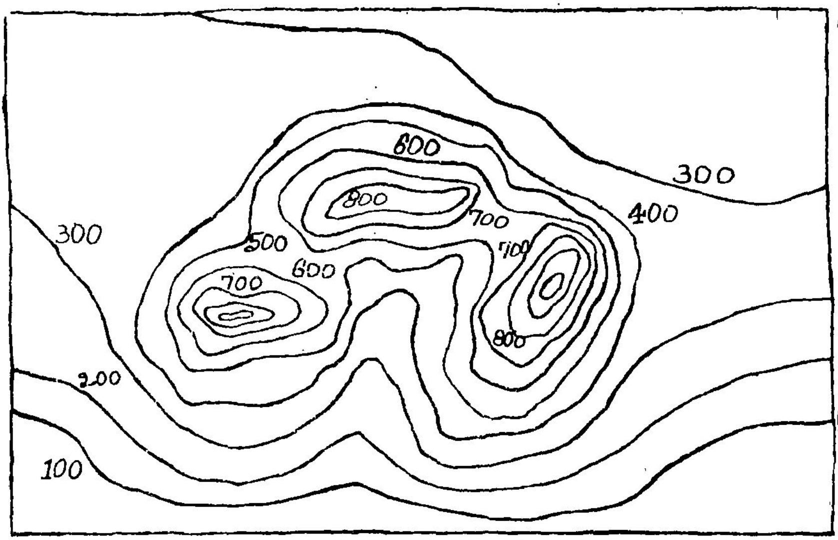

FIG. 75. A CONTOUR MAP OF AN IMAGINARY LOCALITY.

The relief model of a given area, if it is a simple one, can be prepared with tolerable accuracy by the method described below :—

Two copies of the contour map of the given locality (Figure 75) are traced on a sheet of good plywood of the same dimensions as the map, with the help of carbon paper. As it is desirable to have the vertical scale slightly increased (lest the elevations should escape recognition in the model) and as the vertical scale is proportionate to the thickness of the plywood, plywood of $\frac{1}{4}$ inch thickness would go well with a six-inch map. The odd contours of one sheet and the even contours of the other are sawn out with a fret-saw Figures 76 and 77). Each resulting strip will have three contours on it, two of which will be represented by the two edges, and the third by the unsawn carbon line. The strips are then built up on a flat base, by glueing or nailing them firmly down one over the other in such a way that the outer edge of each over-lying strip lies just over the corresponding central (carbon line) contour of the underlying strip (Figure 78). The result will be what may be called a *contour model*, with the contours running in the form of steps (Figure 79).

The steps are then smoothened out by filling in with any modelling material such as clay or plasticine, without deeply burying any of the edges (Figure 80). When smoothening out the steps,

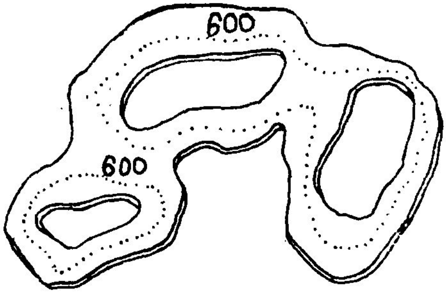

FIG. 76. A CONTOUR STRIP WITH UNSAWN 600-FOOT CONTOURS.

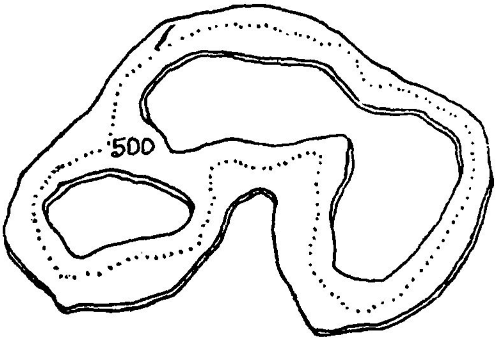

FIG. 77. A CONTOUR STRIP WITH THE UNSAWN 500-FOOT CONTOUR.

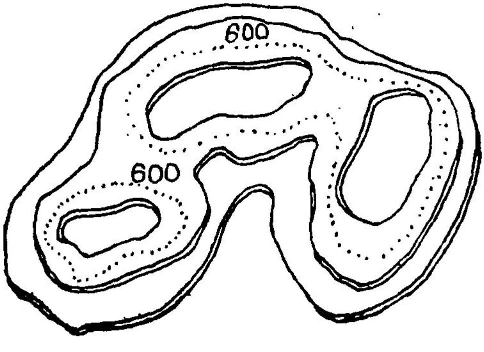

FIG. 78. THE CONTOUR STRIP SHOWN IN FIG. 76 SUPERIMPOSED OVER THAT SHOWN IN FIG. 77.

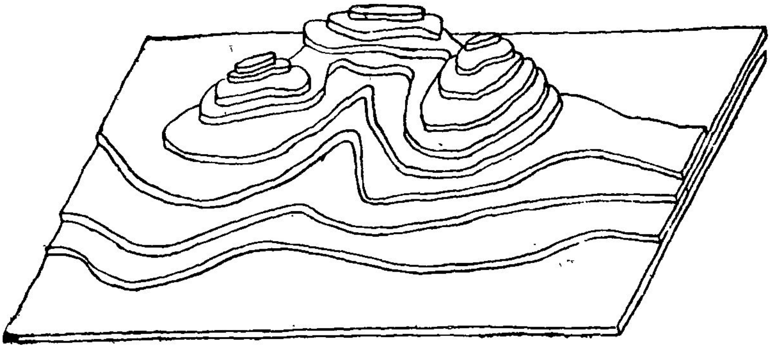

FIG. 79. A COMPLETE CONTOUR MODEL OF THE AREA SHOWN IN FIG. 75.

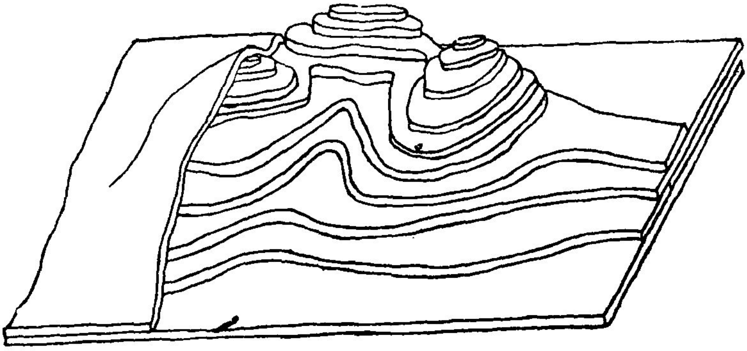

FIG. 80. THE STRIPS OF THE CONTOUR MODEL SHOWN IN FIG. 79, PARTLY COVERED WITH PLASTICINE.

due care should also be exercised upon the interpretation of the slopes, as concave (when contours have larger intervals between them) or as convex (when they run very close). The *contour model* is thus converted into a *relief model* (Figure 81) of which a cast may be taken in plaster of Paris and painted in oil colours. It is needless to add that these models will remain incomplete, unless their horizontal and vertical scales are distinctly stated.

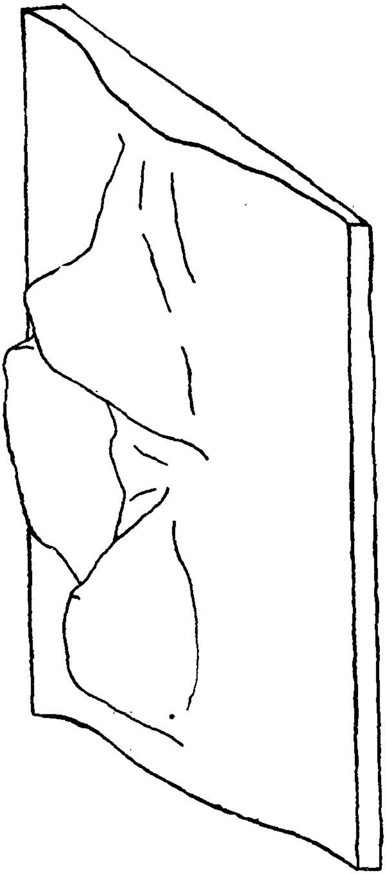

FIG. 81. A PLASTER-CAST RELIEF MODEL OF THE AREA SHOWN IN FIG. 75.

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SECTION IV.

On Coinage and Preservation of Coins.

By P. N. MOHAN DAS, M.A.

(Formerly Curator, Numismatics Section, Government Museum, Madras.)

Introduction.—Numismatics is the study of coins. Its importance to the study of history is great. Numismatics is an important source of ancient history. It confirms, modifies and even amplifies history. To a great extent the political and economic history of a country is constructed by Numismatics and historical facts are very often corroborated or rejected by numismatic findings.

Numismatics is an important source of the political history of ancient India. Our knowledge of the Indo-Bactrian Greeks, the Indo-Scythians, the Indo-Parthians and the Kushan kings is based on their coins. Many facts connected with administration, historical geography and religious history of ancient India are revealed to us by Numismatics.

The evolution of coinage.—The simplest way in which goods changed hands was by barter and at that stage of economic development there was no need for a medium of exchange. But as economic conditions became more and more complex, people began to feel the necessity for a common medium of exchange.

The first stage was marked by the use of some article of common use, such as shells which were used as medium of exchange in China, India and Africa. Sometimes this was an object which was most commonly and indispensably used in every household; for example, corn, cattle, furs, hides, salt, rice, opium-pills, tea, spades and knives. When these were adopted as a measure of value they became money.

Gradually much inconvenience was felt in using these articles. They were not durable nor portable, nor divisible. As the boundaries of commerce came to be extended, there arose the demand for a common standard—a standard that would satisfy all sorts of persons. This led to the use of metals for coinage. Metals were found to have many advantages. They are durable, portable, homogenous and easily divisible. They are also resistant to destruction and valued as ornaments.

At first metals were used as such, as currency. A given weight of a particular metal was used as the common medium of exchange. This was found to have many disadvantages because it necessitated the constant use of weighing balances. The method of striking

coins was adopted to overcome this disadvantage. It must however be noted that it took many years before the method of coinage was invented and finally adopted.

The material used for coinage.—Almost all metals have at some time or other been used as material for coinage. Iron was used in the Peloponnesus in the fifth century B.C. and again in Japan even to a recent time. Lead was used in Roman Egypt, and in Roman Gaul and by the Andhra Satavahanas in ancient India and in Denmark as late as the 17th century. Tin was used in Rome. Tin half-pennies and farthings were current coins in England up to 1692. Brass was used by the early Roman Emperors and nickel by the Kings of Bactria after 200 B.C. The other metals used are electrum, potin and billon. But the most commonly used metals have been gold, silver, copper and bronze.

The technique of coinage.—In the beginning the metals were kept in their natural state. Later on they were kept in lumps. In India coinage seems to have begun with the " punch-marked " coins.

The word " punch-marked " has been used in contra-distinction to " die-struck ". A die covers the whole or very nearly the whole of the face of a coin; but a punch covers only a small portion of its surface so that the blank of a coin is impressed not by one but by many separate punches. The face of the coin thus consists of a regular net-work of punches often overlapping.

In the West, in Asia-Minor and Greece, the earliest coins were small ingots of metal with a punch. The earliest coinage of China consists of three kinds, spade money, knife money and ring money. The first two are peculiar as they provide examples of coins made in the likeness of the primitive barter units which they resemble. They succeeded a currency of real spades and real knives. The earliest method of producing these coins was to run the molten metal into moulds, the moulds being of bronze, stone, earthen-ware, beaten-clay or iron.

The development of the technique of coinage was marked by many stages. The latest development was to strike them from dies. But before it was finally adopted various intermediate experiments had to be gone through and the double die-struck coin was finally adopted.

Terms used in the description of coins.—The following terms are commonly used in describing coins :—

1. *Flan.*—The metal disc or body which receives the impress of the die.

2. *Obverse and reverse—The face and back of a coin.*—As regards the earliest coins, the obverse is the side which received its impression from the lower side, the die being supported by the

anvil, the reverse is the side which received its impression from the upper die. But as regards later and modern coins, the side bearing the head of the principal device is commonly described as the obverse and the side showing the device of secondary importance as the reverse.

3. *Field.*—The area or surface of a coin on which the type, legend, etc., are shown, sometimes enclosed by a rim.

4. *Type.*—The most salient feature or characteristic of the design.

5. *Symbol.*—On ancient coins, a small accessory device, unconnected with the type and having an importance of its own; for example, the mark or signet of an issuing authority or mint officer.

6. *Legend.*—The inscription surrounding or accompanying the type.

7. *Aurum.*—Gold.

8. *Argentum.*—Silver.

9. *Aes.*—Bronze, copper or brass.

10. *Electrum.*—A natural mixture of gold and silver.

11. *Potin.*—An alloy of copper, zinc, lead and silver.

12. *Billon.*—A mixture of silver and copper.

The weight system in ancient India.—In Northern India the base of the metric system was the " Rati " seed (*Abrus precatorius*) which was approximately equivalent to 1·75 grains troy.

The table of weights used in Northern India as is shown in the works of Manu and Yajnavalkya is as follows :—

SILVER.

Grains—				
3·5	= 2 Rati	= 1 Mashaka.		
56·0	= 32 ,,	= 16 ,,	= 1 Dharana or Purana.	
560·0	= 320 ,,	= 160 ,,	=	= 1 Satamana.

GOLD.

8·75	= 5 Rati	= 1 Masha.		
140·0	= 80 ,,	= 16 ,,	= 1 Suvarna.	
560·0	= 320 ,,	= 64 ,,	= 4 ,,	= 1 Pala ar Nishka.
5600·0	= 3,200 ,,	= 640 ,,	— 40 ,,	= 10 ,,

COPPER.

140·0 = 80 Rati = 1 Karsha Pana = 1 Dharana.

In Southern India, the monetary system was based upon the weights of two kinds of seeds of indigenous origin, namely, the *Manjadi* (*Adenanthera pavonina*) weighing about 5 grains of troy, and the Kalanju or Molucca bean (*Caesalpinia bondue*) weighing 10 manjadis or 50 grains.

The punch-marked silver coins of the South are equivalent to the Kalanju in weight and the gold fanam of Southern India to the manjadi seed. The gold varaha or pagoda is the equivalent of the Kalanju seed.

The punch-marked coins or puranas.—The punch-marked coins are the earliest Indian coinage. They are so called because the devices on the coins are impressed, not by means of a die covering the face of the coins, but by separate punches applied irregularly at various points on the surface. Usually the obverse shows larger number of symbols and the reverse none or at the most one or two symbols or marks. In Hindu and Buddhist literature these coins are referred to as Puranas. The Satamana coin which Panini refers to in his work is a particular variety of the Purana. The Satamana is the heavy bent bar of silver with devices stamped out with a punch on one side. The Purana usually weighs 56 grains, while the weight of the Satamana is 560 grains, ten times that of the Purana. The symbols on the punch-marked coins have been classified under six groups—(1) human figures, (2) implements, arms and works of man, for example, stupa or chaitya, bow, arrow, etc., (3) animals, (4) trees, branches, fruit, (5) symbols connected with Solar, Planetary or Saivite worship and (6) other unknown symbols.

The punch-marked coins were in use in Northern India from the earliest time to the beginning of the Christian era at least. The silver Karshapana of 56 grains was the standard coin of the Mauryan Empire. In Southern India the circulation of punch-marked coins was perhaps continued for 300 years more.

Coins of Southern India—How to identify them.—Coins are usually identified by studying the figures, the emblem, the legend and the date on them.

Various forms of letters have been prevailing in the history of Southern India. Taking the lettering of the earliest Asokan rock inscriptions as a basis, we have in order of time, (1) the cave characters, (2) the Chera, Chalukya and Vengi, (3) the old Grantha, Purva-hala-Kannada, Vatteluthu, West Chalukyan, East Chalukyan and Nagari, (4) old Tulu, middle Grantha, Hala-Kannada, old Telugu and Devanagari, (5) Modern Tulu, Malayalam, Grantha, Tamil, Kanarese, Telugu and Nandi-Nagari characters.

The eras most commonly used are the Kaliyuga, the Saka or Salivahana era, the Kollam era and the Brihaspati era of the Jains. Numerals are expressed by words and by letters.

The emblems of the important South Indian dynasties.—(1) The Andhra Satavahanas. The elephant is the most common emblem. The horse and the lion are also shown. On the reverse is commonly found the Ujjain symbol, so called from the old Asokan letters bearing that name. (2) The Pallavas—the seals

on the Pallava copper charters have the figure of a bull recumbent or standing. But it may be noted that no coin bearing this emblem has been discovered yet. (3) The Kadambas, who are said to have ruled over the Malnad or West Mysore had the figure of a lion looking backwards as their emblem. The monkey-god Hanuman is also found. (4) The Chalukyas—the insignia of the Chalukyas consisted of the boar, the peacock fan, the ankusa (elephant goad), the golden sceptre, the banner of the sharp sword, a drum, the simhasana. (5) The Rashtrakutas—the Rashtrakuta coins show the head of the king on the obverse and a bull couchant on the reverse, (6) The Kalachuris who ruled Northern Mysore had the golden bull and the Garuda on their coins. (7) The Yadavas of Devagiri had the golden Garuda as their emblem. (8) The Hoysala Ballalas who ruled over Mysore had the figure of a tiger on their coins. (9) The Chera, Kongu and Gajapati dynasties. The cognizance of the Cheras was a bow. The Kongus adopted the figure of an elephant in addition to the Chera bow. The Gajapatis had the elephant as their emblem. (10) The Gangas had the bull as their crest. (11) The distinctive device of the Cochin and Travancore dynasties was the sankha or the conch shell. (12) The Pandyas —The special emblem of the Pandyas was the figure of a fish in various combinations. (13) The Chola coins bear the Chola emblem, the tiger in the centre, with the Pandyan and Chera emblems (fish and bow) on either side of it. (14) The Vijayanagar dynasty—The "varaha" or the boar with a sword was the chief emblem of the coins of this dynasty. But the bull, the Garuda, and the elephant also appear on their coins at various times. (15) Mysore—The Mysore coins have the emblem of the figure of the elephant and the figures of Siva and Parvati.

Coins issued by foreign settlements in Southern India.—The Portugese, Dutch, Danish, French and the English were the European powers that issued coins for use in their settlements in Southern India.

Portuguese coins.—The Portuguese coins do not bear any inscription or word in a native language. A very large number of these coins bear initial letters or abbreviations which stand for the name of the sovereign or the denomination of the coin.

Danish coins.—Danish coins consist mostly of four cash pieces in copper and very rarely of the cash in silver and copper. All of them bear on one side the monogram of the reigning monarch. On the other side of the earlier issue is found the monogram of the Company and in later issues "X" or "IV KAS" as the case might be, with the date below. The coins most commonly found are those of Chritian VI, Christian VII, and Frederick VI.

French coins.—The French have issued silver and copper coins. These coins bear on the obverse either the cock or fieu detis. On the reverse is found either the date or the word " Pondicherry " in Tamil.

Dutch coins.—The early Dutch coins consist of 2, 1, ½, ¼, and ⅛ silver pieces. They were stamped with the value of the coins. The later ones bear the monogram of the Company formed by the three letters V.O.C. (Vereinigtė Os tindiche Compagnie).

English coins.—The English East India Company minted coins for the use of their settlements from the beginning of their existence. The Madras mint was in existence from about 1661. From this mint were issued the Pagodas—the single swami pagoda, the old star pagoda, the three swami pagoda and the mohur in gold and the star pagoda in silver.

The pagoda or the varaha bears the figure of Vishnu singly, or together with his two consorts. The Mohur has on one side the arms of the Company and the inscriptions in English, "English East India Company". On the other side is found the Persian inscription, which translated into English reads, " Ashrafi of the Honourable English Company".

The silver star pagoda has the temple gopuram on one side and the other side has the figure of Vishnu.

The English Company also issued cash and pie coins in copper.

In 1816 the rupee became the standard coin of the English in Southern India.

Preparation of models of coins.—It may not be possible to exhibit the coins in original to the public on grounds of safety. Therefore plaster cast impressions of the coins are prepared and exhibited in public gallaries.

The impression of the coin is first taken on sealing wax and on this impression is poured the plaster of Paris solution. The plaster cast impression is then filed, cut to size and painted the colour of the metal of the coin. This is the cheapest and easiest method of preparing models of coins.

APPENDIX I.

MATERIALS USED FOR PREPARING MODELS.

1. Thick cardboard.
2. Sealing wax.
3. Plaster of Paris.
4. Quick-drying paint—Gold, silver and copper.

APPENDIX II.

SOME ADDRESSES OF COIN DEALERS.

1. Ghoshal & Co., 85, Tantipara lane, Santragacha, Howrah, Calcutta.
2. V. Chockalinga Mudaliyar, Retired Superintendent, Public Works Department, 7/1, Dr. Menon Road, Kodambakkam, Madras.
3. M. Sitaram, 2452, Ayyankadai Street, Tanjore.
4. J. K. Agarwal, M/s. Krishna & Co., Chowk, Lucknow.
5. Chelikani Krishna Rao, Landlord, Grasa Post via Pithapuram, East Godavari district.
6. N. L. Shenai, P.B. No. 6007, Bombay-12.
7. S. T. Sreenivasagopalachari, "Sambanda Vilas", Raja Annamalai Chettiar Road, Purasawalkam, Madras-7.
8. Hans, M. F. Schulman, 545, Fifth Avenue, New York, 17, N.Y.
9. Stack's, 12, W. 46th Street, New York, 19, N.Y.

APPENDIX III.

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1. Coins of India by C. J. Brown.
2. Hints to Coin Collectors in Southern India by Capt. R. H Campbell Tufnell.
3. Coins of Southern India by Sir Walter Elliot.

SECTION V.

Materials for History.

By P. R. SRINIVASAN, M.A.

(Curator, Archaeological Section, Government Museum, Madras.)

Introduction.—The science of Archaeology has two distinct parts, one dealing with the study of pre-historic antiquities and the other with the study of materials relating to the historical times. The latter group of antiquities is the theme of this section. They fall into various groups such as inscriptions, examples of architecture, sculptures, paintings and terra-cottas. A careful analysis of the various details of items of each one of these groups is essential for a proper understandnig of the growth and development of Indian culture. In the ultimate analysis, it will be found that Indian culture is a composite one where influences from various quarters and traits of several cultures have become naturalized and assimilated with the result that though it is not absolutely Indian in character, yet its roots and bases are the creations of Indian genius. Before launching upon a detailed study of the various aspects of Indian culture and history, it is necessary to know about their fundamentals, and they are briefly dealt with in the following paragraphs.

Outline of Indian History—North India (Early dynasties).—The history of Indian culture commences from the 3rd millennium B.C. when the Harappa culture flourished, which is represented by the large number of antiquities found at Mohanjo-Daro and Harappa (both the places now in Pakistan). A study of these remains has enabled us to know that the people of the Indus valley had a highly refined urban civilization. As the writings on the seals, examples of which have come down in large numbers, have not yet been deciphered, it is not possible to know more definitely and in greater detail the real character of the culture.

This culture is said to have been superseded about 1500 B.C. by the culture represented by the Vedic literature. A study of Vedic literature gives a glorious picture of the life of the Indians up to about 600 B.C. Unfortunately, except examples of pottery this period is not represented by any other significant groups of antiquities or monuments. Nor is the history, pieced together from the historical references contained in Vedic literature, free from ambiguity and doubt. But one thing becomes clear that during the last phase of this period, the Indians developed their mental faculties to unprecedented heights.

From about the 6th century B.C., the history of India becomes clearer. At the commencement of this period, the Saisunagas and the Nandas were ruling in Magadha. The rule of the latter dynasty

lasted till about the 4th century B.C. This period witnessed the coming into being of the two great religions, namely, Buddhism and Jainism. As a consequence, a vast literature bearing on these religions as well as on Vedic religion was produced during this period. Since actual remains of the mater al culture of this period are not many, we have to rely on this religious literature for our knowledge about the development of the culture of this period.

The Mauryas.—The rule of the Nandas ended in the 4th century B.C. Then a powerful dynasty headed by Chandragupta Maurya began to rule from about 320 B.C. With the able assistance of his famous minister Chanakya, Chandragupta extended his empire over the whole of North India. He is said to have met Alexander, the great Greek adventurer. The grandson of Chandragupta, the world-renowned Asoka, was able, by peaceful means, to extend his empire even beyond the borders of India into Central Asia. The southernmost part of India remained outside Asoka's empire and was ruled by the three ancient royal dynasties, namely, the Cheras, the Cholas and the Pandyas. After his conversion to Buddhism, Asoka strove hard to propagate Buddhism by various means. One of the means he employed was erecting and excavating monuments in stone, such as stupas, monumental pillars and rock-cut caves. Thus Buddhism began to attract a larger following, and due to the royal patronage extended to its followers, Buddhism held a pre-eminent position in India for nearly six centuries. So, monuments of Buddhism of this period have come down to this day in large numbers, and they are scattered all over India. Asoka was also responsible for the introduction of Buddhism in Ceylon, where Buddhist monuments during from the 3rd century B.C. are still to be seen. Asoka seems to have sought the assistance of artists and architects of the Persian empire to achieve the best results in the works of art and architecture which he caused to be created.

The Sungas.—The great creative Mauryan period was over by about 180 B.C. Then the empire disintegrated and its various parts came to be ruled over by several smaller dynasties. The central region was taken possession of by the Sungas, a Brahminical dynasty, who by performing Vedic sacrifices declared their policy of reviving Brahminism. The famous kings of the dynasty were Pushyamitra and Agnimitra who is said to have been the hero of Kalidasa's Malavikagnimitram. Even though they were avowed followers of Vedic religion during their rule there was no persecution of other religions. On the contrary, their tolerance is proved beyond doubt by the stupas of Bharhut and Sanchi belonging to their period. The Sungas were followed about the beginning of the 1st century B.C. by the Kanvas who ruled till about the end of the 1st century B.C.

The Kushanas.—The north-western part of India was, from the time of Alexandar's visit, changing hands and it was ruled over sometimes by Scythians and sometimes by the Parthians about 2nd-1st centuries B.C. The Kushanas, an Indo-Scythian dynasty, came

to power in this area about the 1st century A.D. and Kanishka, the most colourful member of this dynasty, who ruled from Peshawar at the beginning of the 2nd century A.D., extended his domain into Central and Eastern India also. Kanishka was a Buddhist and like Asoka, he was also interested in propagating Buddhism. One of the ways he adopted for this was the erection of monuments. The Kushan period witnessed the growth of two schools of architecture and art, the one in the north-west region called Gandhara and the other at Mathura. The two styles were distinct so far as the technique is concerned but the subject they treated was Buddhist legends and stories. The Gandharan art was influenced by the art traditions of Greece and Rome in their decadent form, whereas the Mathura works were in the purely indigenous way. The Gandharan art traditions, however, disappeared about the 5th century A.D. without leaving behind any marked traces in the art traditions of the subsequent period.

The Deccan and Southern India.—*The Andhras and the Kshatrapas.*—The Andhra dynasty came to power about 200 B.C. in the region now represented by the modern Bombay Province. They were at loggerheads with the Kshatrapa kings who held sway over the Gujarat and Kathiawar regions. The Andhras slowly extended their way over the entire Deccan and reached the east coast also, where they were supreme in the Krishna-Godavari region till about 250 A.D. During the period of these kings a number of rock-cut caves were excavated in the Western Ghats and stupas were erected, the Sanchi and Amaravati stupas being the most important of them.

The Kalingas.—The south-eastern part was secured by the Kalingas and they ruled here from about 200 B.C. for two or three centuries. Kharavela, the Jain king was the most distinguished member of this family and it was during his period the famous Jaina caves in the two hill ranges of Orissa, namely, Khandagiri and Udayagiri, were excavated.

From a long time before Asoka the southern-most part of India was ruled over by the three famous royal dynasties, namely, the Cheras, the Cholas and the Pandyas. In the Asokan edicts they are mentioned as good neighbours which obviously means that Asoka maintained friendly relationship with these powers. They continued to rule over this region for a long time after Asoka, sometimes suffering temporary oblivion but soon emerging with redoubled vigour. Although there is a great deal of traditional and literary evidence regarding these dynasties no antiquities of undoubted date have been discovered about them. But there is no doubt that there was brisk literary activity during this period as testified to by the famous works in ancient Tamil such as the Tolkappiyam, a treatise on grammar, the Tirukkural, a treatise on morality and ethics, the Tamil anthologies, and the epic-like works, the Silappadikaram and Manimekalai. A number of Roman gold coins of the first three centuries A.D. as well as a few inscriptions of uncertain date are the only archaeological data available for the

history of the material culture of the early Tamil kingdoms. Recently some antiquities dating definitely from the 1st century A.D. have been brought to light at Arikamedu near Pondicherry. Other evidences of material culture of this part of India, especially architectural works, are available only from 600 A.D.

Migration of Indian culture.—It was during this early period that there was a migration of Indians from North India to countries in the South East Asia such as Cambodia, Indo-China, etc. In those places have been discovered evidences of Indian culture dating from the 1st-2nd centuries A.D.

The Guptas.—After the Kushanas, the central part of North India was ruled by the Guptas, of whom Samudragupta and Chandra Gupta II, Vikramaditya, were famous. During their time the Gupta empire covered almost the entire northern Indian and a portion of south-eastern India and the Deccan. No other dynasty since the Mauryas possessed such a large dominion as the Guptas. Their rule commenced about 320 A.D. and lasted till about 600 A.D.

The Vakatakas.—Contemporary with the Guptas and in fact connected with them by marriage were the Vakatakas of the southern Vindhya Pradesh. They also ruled from the 4th century A.D. till the 7th century A.D.

The Kadambas.—In the western part of India the Kadambas were ruling till about the 6th century A.D. when they had to yield to the Chalukyas of Badami.

The Gangas of Kalinga were contemporary with the Guptas and they were ruling here for a long time.

South India—Early dynasties.—The Ikshvakus were in possession of the Krishna valley in the 3rd century A.D. when the Andhra power waned. They were succeeded by the Salankayanas and the Vishnukundins who ruled till about the beginning of the 7th century A.D

The Early Pallavas.—They are mentioned in the Prakrit grants and were ruling over the region called Tondaimandalam from the close of the Andhra period till about the 6th century A.D. Their capital was Kanchipuram. From the end of the 6th century A.D. the well known line of the Pallavas headed by Simhavishnu began to rule and it lasted till the 9th century A.D. As has already been said, there is evidence to prove the existence of the rule of the three ancient dynasties of kings in this part during this period also.

North India—Later Dynasties.—The period from 300 to 600 A.D. is represented by a vast number of architectural monuments. In North India the Guptas started building Hindu temples of a simple variety and erected pillars of victory including the famous iron pillar of Meharauli. In the Deccan the Vakatakas, the Kadambas and the Chalukyas continued the practice of excavating

rock-cut caves devoted to all the three religious, namely, Brahminism, Buddhism and Jainism. In the east of India also a few Buddhist and Hindu antiquities, though not examples of architecture, have been discovered representing the period.

From about the 6th century A.D. North India was ruled over by a number of dynasties. In the seventh century the Vardhanas of Kanauj were ruling over the entire North India. Harsha Vardhana was famous amongst them. The eastern part of North India was ruled by the later Guptas and the Gaudas. Then from the eighth century the Palas came to power here and their reign lasted till about 1100 A.D. After the Vardhanas a number of Rajput dynasties began to rule in the western part of North India.

The Deccan and South India—Later Dynasties.—This region was in the possession of three important dynasties from about the 7th century A.D. The Chalukyas of Badami ruled till about the middle of the 8th century. They were succeeded by the Rashtrakutas whose rule ended in the 10th century A.D. Then the later Chalukyas of Kalyan began to rule. Contemporary with these later Chalukyas were the Kalachuris, the Solankis and the Yadavas. Finally these dynasties were all overthrown by the Muslim invaders about the 13th century A.D. But in Mysore the Hoysalas were powerful from the 11th century A.D. to the 14th century A.D.

In the south-eastern part of India, the Eastern Chalukyas of Vengi were ruling for nearly six centuries from about 620 A.D. Afterwards this kingdom was annexed to the Chola empire. In the southern part of India the Pallavas were powerful from 600 A.D. to 850 A.D. Then the Chola dynasty asserted its independence and was master of the whole of South India by about the beginning of the 11th century A.D. Their rule continued till the end of 13th century A.D. Contemporary with them were the Pandyas who suffered defeat sometimes and were back in power at other times. But about the end of the 13th century A.D., they re-asserted themselves in South India and their rule lasted for about a century and a half thereafter.

From about the 13th century A.D. North India came to be dominated by the Muslim rulers belonging to the dynasties such as the Slave, the Khalji, the Suri, etc. In the 16th century A.D. the Mughals came to power and their rule lasted for more than two centuries. Then the British usurped their power. During the Muslim rule there were a number of independent Rajput principalities in Rajasthan and the Himalayan regions who kept alive the ancient traditions of culture, art and architecture of Bharat.

In the Deccan, there were a number of Muslim kindgdoms till about the 17th century A.D. But in the southern part of the Deccan there rose to power the famous Hindu empire called the Vijayanagar empire. It stood as a bulwark against the Muslim onslaught from about 1350 A.D. till 1600 A.D. The Vijayanagar kings including the famous emperor Krishnadeva Raya slowly

extended their sway over the entire South India and Southern Deccan, and they entrusted the administration of the different parts of their empire to their Viceroys called the Nayakas. The Nayakas of the Vijayanagar kings were ruling from Tanjore and Madurai. The Nayakas asserted their independence about the 16th century A.D. when the power at the centre was at its lowest ebb. The rule of the Nayakas over these territories lasted nearly a century. At Tanjore the Nayakas were overthrown by the Mahrattas. The subsequent history of the British period is common knowledge.

Epigraphy—General.—Amongst source materials of ancient history of India inscriptions are important. The study relating to them is called *Epigraphy*. Inscriptions are in different scripts, the study of which is called *Palaeography*.

Materials employed for engraving writings were varied, slabs of stone nad sheets of metal being the commonest. Copper-plates and sheets of other metals such as gold, silver and bronze were used for the purpose. The famous Meharauli iron pillar with the inscription of King Vikramaditya is a unique example in which the surface of an object made of iron is used for carving inscriptions on. The technique of inscribing on the various materials, in olden times, was simple. The surfaces of the objects were well prepared and the writing was done first in ink or other erasable materials, prior to chiselling the letters.

Scripts—In India, the earliest extant examples of writing are those found on the seals from Mohenjo-Daro and Harappa, the typical sites of the Harappa culture which flourished between 3000 and 2000 B.C. The script of the seals is a variety of picture-writing (Fig. 104) which, owing to lack of clues, has not yet been deciphered.

The period from about 2000 B.C. to about the end of the 4th century B.C. is not represented by any inscribed antiquity. However, the vast body of Vedic, Buddhist and Jain literature attributed to this period suggests that the people should have known the art of writing. This fact is proved beyond doubt by the famous Asoka's edicts. The forms of letters of the script employed here are highly developed and the alphabet is phonetic which is quite different from the pictographic or ideographic writing of Mohenjo-Daro.

Inscriptions in ever increasing numbers are met with in each of the historic periods after the 3rd century B.C. A great majority of them, however, are from South India. These inscriptions are in a variety of scripts and it is a fascinating study to trace the development of a modern script stage by stage from its origin to its final form.

At the time of Asoka only two scripts were employed for writing viz., ***Kharoshti*** and ***Brahmi***, (Fig. 82) the former confined to the North-West Frontier Province of undivided India, and th

latter found throughout the rest of India. Kharosht disappeared totally from India about the 5th century A.D., " without leaving any descendant ". Through the contacts established by Asoka, the earliest inscriptions of Ceylon are also in Brahmi. In the Madura, Ramanathapuram and Tirunelveli districts there are natural caverns in the rocks containing inscriptions, which are written in a slightly variant form (Fig 83) of Asokan Brahmi.

The Brahmi script was in vogue throughout India for a pretty long time (Figs. 84 and 85) till about the 4th century A.D. But it was slowly changing as time went on and about the end of the 4th century A.D., it began to assume definite local forms in the different regions. The derivative Brahmi that came to be used for writing in North India since the time of the Guptas was called the Nagari (Fig. 86). After a long period it underwent changes in the various regions of North India, finally to assume the forms of the scripts such as the Bengali, the Sarada, the Gujarati and the Nepali, of modern times. The Nagari script of the Gupta times was also the one used for writing in the Kalinga (modern Orissa) country for a long time. In the Deccan the earliest derivative of Brahmi (Fig. 87) was Old Kanarese. This was in vogue for a few centuries and later on it developed into the modern Kanarees. In the Andhra country a variety of Old Kanarese script (Fig. 88) was found employed in inscriptions dating between the 7th and 9th centuries A.D. Afterwards the script assumed an independent form which was called the Telugu. In the country south of the Krishna four derivative scripts of the earlier Brahmi were employed in the inscriptions. They are the Vatteluttu, (Fig. 89) the Grantha (Fig. 90), the Tamil (Fig. 91), and the Nagari (Fig. 92). Of these the Vatteluttu was universally employed for writing in the West Coast from about the 8th to about the 16th century A.D. The other three scripts were used by the people of the Pallava and Chola countries. During the Vijayanagar period inscriptions were written in all the scripts that are now in vogue in South India including the Nagari which was then called Nandinagari (Fig. 93).

Language—The language of the Mohenjo-Daro picture-writing is not yet known. A great majority of inscriptions belonging to the period from Asokan to about the 4th century A.D. are in Prakrit. But the language of inscriptions of each region is a dialect of Prakrit. The earliest inscriptions of the Tamil country are, however, in Tamil. This early period is not, however, devoid of inscriptions in Sanskrit but examples are few and far between. At Nagari and Ghosundi in Udaipur State are inscriptions, dated to about 150 B.C., which are in Sanskrit. From about the third century A.D., Sanskrit gradually replaced Prakrit in the inscriptions of the whole of India except the far South, because Sanskrit was used by kings and officials for administrative purposes. During the short transitional period a kind of mixed dialect was employed. The passages of pure Sanskrit inscriptions are either entirely in prose or in verse or in

prose and verse. From about the 6th-7th centuries A.D., especially in the Deccan and the East Coast, regional languages such as Kanarese and Telugu came to be used. In the far South, the cave inscriptions and the graffiti found at Arikamedu near Pondicherry

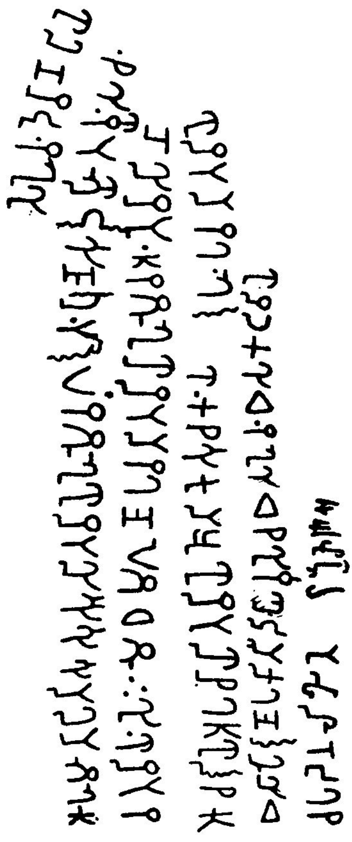


FIG. 82. ASOKAN BRAHMI.

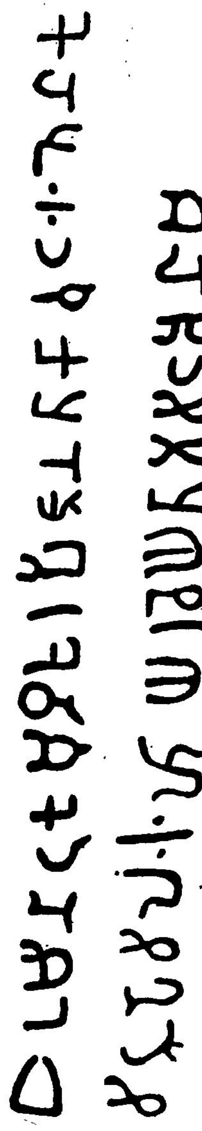


FIG. 83. BRAHMI OF TAMILIAN CAVES.

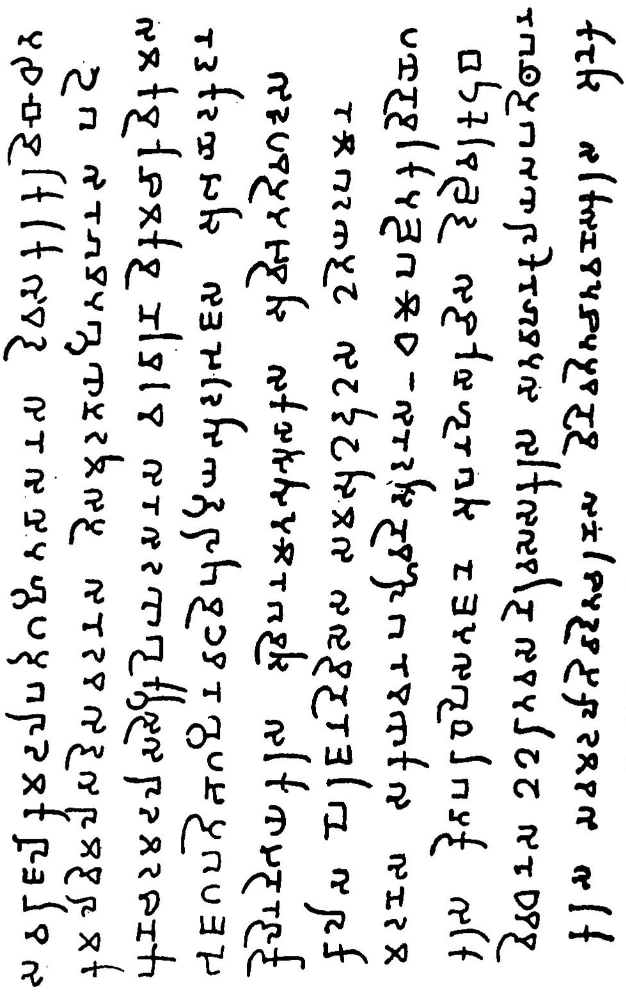


FIG. 84. BRAHMI OF RUDRADAMAN'S TIME (2ND CENTURY A.D.).

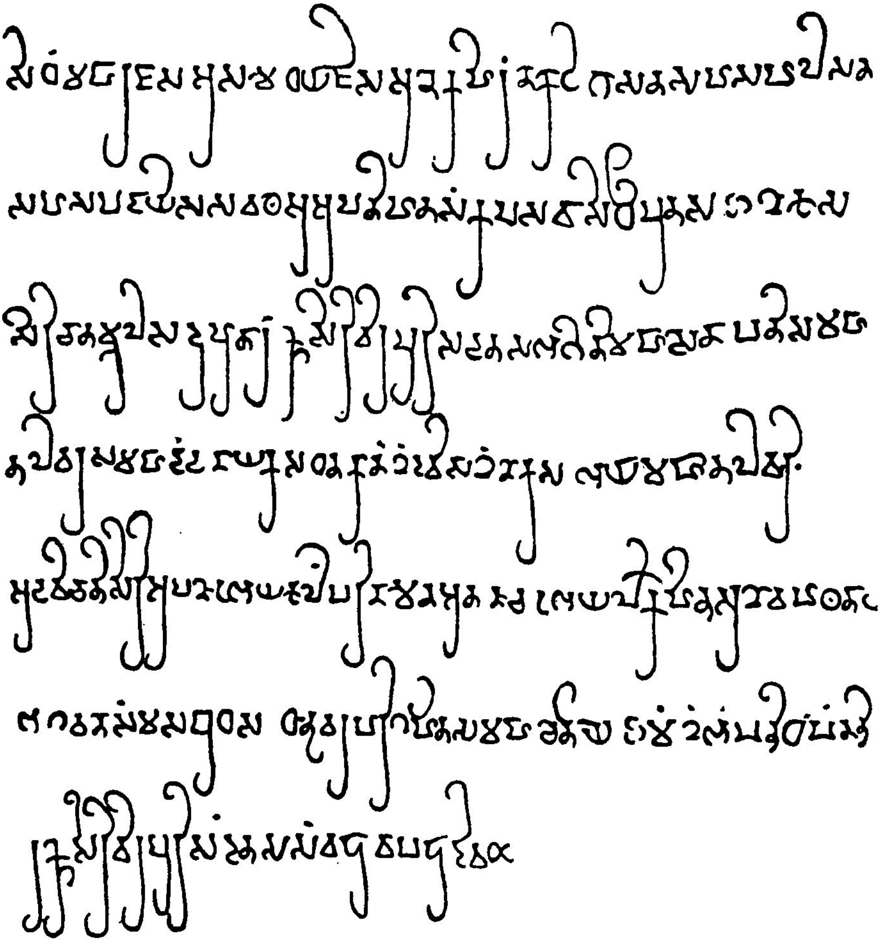


FIG. 85. BRAHMI OF 3RD CENTURY A.D. FROM JAGGAYYAPETA.

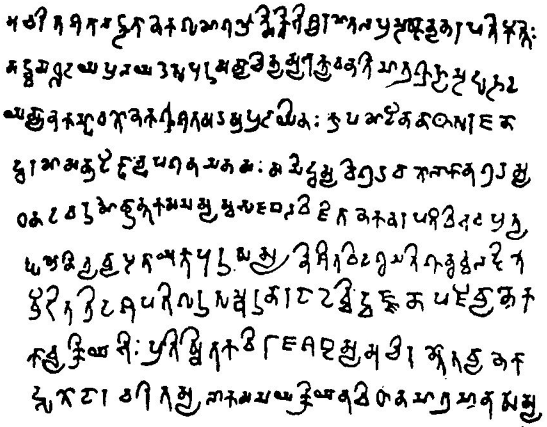


FIG. 86. NAGARI OF THE GUPTA PERIOD.

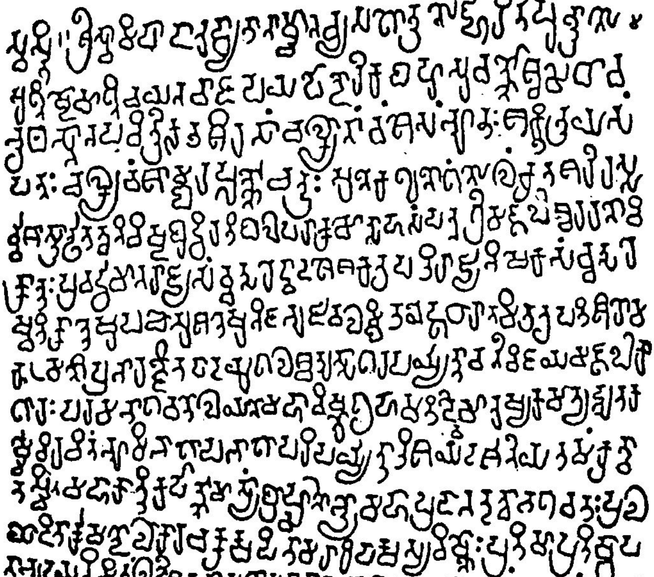


FIG. 87. EARLY CHALUKYAN SCRIPT.

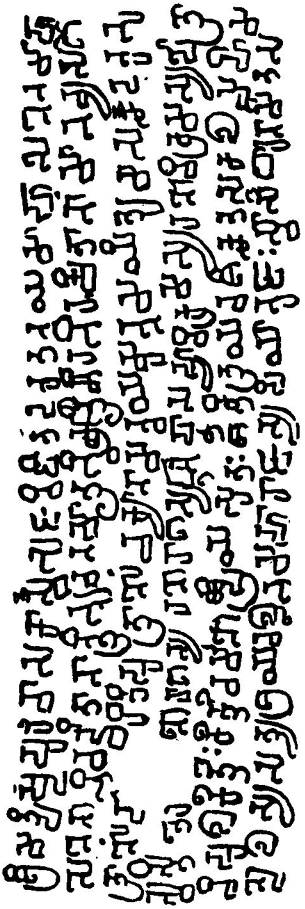


Fig. 88. Vengi Chalukyan script.

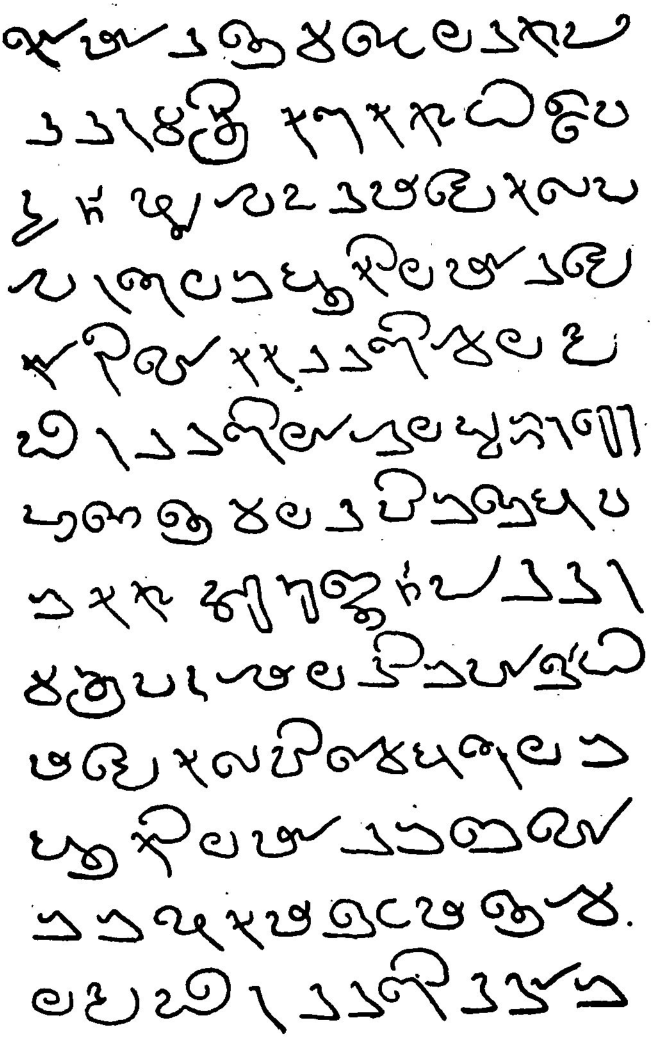


FIG. 89. VATTE

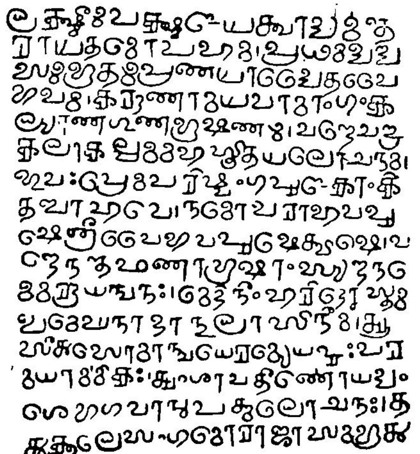


FIG. 90. GRANTHA SCRIPT.

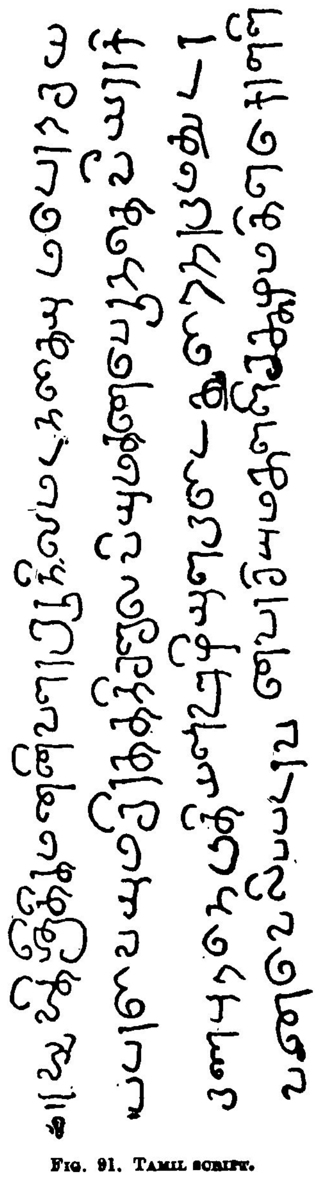


FIG. 91. TAMIL SCRIPT.

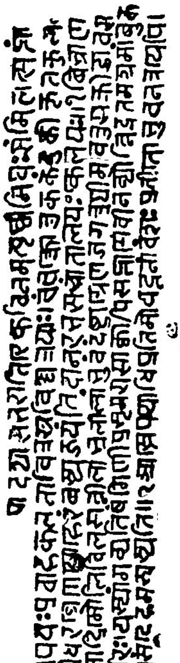


FIG. 92. NAGARI SCRIPT

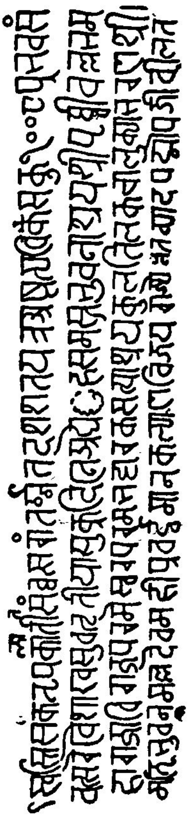


FIG. 93. NANDINAGARI SCRIPT

during the excavation of 1945, dated to about the first century A.D. are in Tamil, while the early copper charters of the 3rd-4th centuries A.D. are in Prakrit. The copper charters of about the 7th-8th centuries A.D. from places on the West Coast are also in Tamil. During the Pallava and early Chola periods both Sanskrit and Tamil were used. Similarly both Kanarese and Sanskrit were used in the Deccan while in the inscriptions of the Andhradesa, Telugu and Sanskrit were used. But from about the 10th century A.D., inscriptions were entirely in the various local languages except for one or two verses in Sanskrit at the beginning and end in some inscriptions.

Contents.— The inscriptions are generally the records of achievements of a king or of donations or of dissertations on morality and good conduct. From the inscriptions the use of a variety of eras

such as the Vikrama, Saka, Gupta, Kali, Ganga, etc., which were in vogue in different parts of India at different times are known. Various astronomical details given in them are helpful in fixing the dates of many a royal dynasty. Names of kings, poets, sculptors, etc., who are otherwise unknown, are known from them. For example Asoka is mentioned by name in his Maski Gujarra edicts; Pushymitra in an inscription from Ayodhya; and the Greek king Menander of the Milindapanho fame is mentioned in an inscription from the North-West Frontier Province of Pakistan. The existence of royal dynasties such as the Maghas, the Nalas, the Ikshvakus and the Salankayanas was established by their inscriptions discovered recently which incidently proves beyond doubt the veracity of the Puranic statements about the dynasties.

Information about various sacrifices, educational institutions, social practices, religions, festivals, administration, unknown places and a variety of other matters is available from inscriptions. Besides some of the inscriptions are written in beautiful language and are the only surviving examples of the literary skill of their authors.

Muslim Inscriptions.—From about the 11th century A.D. a number of Muslim inscription are met within India. They are engraved on mosques, tombs, stone tablets, copper-plates and coins.

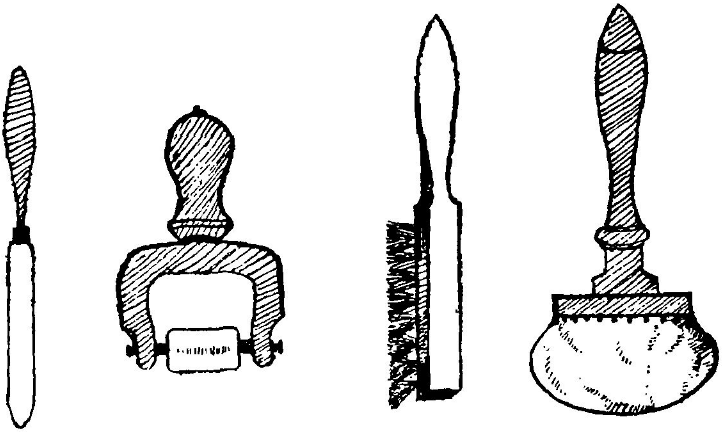
Scripts.—The Muslim inscriptions are krittn in different scripts such as the Kufic, Naskh, Bihar, Thulbth, etc. They are all extremely artistic in form and ingenious in device. Of these, the Kufic was reserved for inscribing passages from religious works such as the Quran. The inscriptions on the tombs of Sultan Ghari (1231–32) and of Sultan Iltumish (1235) are in the Kufic script. The Kufic is said to be the source of other scripts. But there are inscriptions in the Naskh script from about the 7th century A.D. The Naskh script is simple and it replaced the Kufic in the 13th century A.D. This script has a variety of forms such as the florid and the simple. This difference is due to the skill of the calligraphists. Before it came to India the Naskh reached perfection in Iran. The script called Nastaliq, a derivative of the Naskh in Iran, came to India in the 16th century A.D., and was preferred by the Mughal emperors. From now the Naksh was reserved for writing religious passages alone.

Languages.—The earliest extant Muslim inscriptions of India are in Arabic, the religious and literary language of the Muslim world. It was in vogue till the 13th century A.D. During this period a few inscriptions in Persian were also engraved on some tombs. During the period of the Khalji, the Tughluq, the Sayyid and the Lodi dynasties, Persian was the language of inscriptions. During the Mughal period due to Iranian influence there came into being Urdu, a hybrid of Persian and Indian languages. Urdu then became the language of inscriptions, while Persian was confiued to literary works alone.

Contents.—The Muslim inscriptions contribute much to the reconstruction of the history of India during the Muslim rule. Some inscriptions contain passages from the Quran, some are dissertations on ethics while some perpetuate the traditions of the founder.

Technique of Preparing Impressions of Inscriptions.—Inscriptions are usually found on rock faces, sculptures, stone pillars as well as copper-plates and coins. For purposes of study it is absolutely essential to take exact impressions directly from the inscriptions. There are two methods of taking such impressions. One of the two methods is for making impressions of large inscriptions found on walls, stone tablets, etc., and the other for making impressions of portable inscriptions on metal sheets, etc.

Material required for the work—For large inscriptions.—(1) water, (2) thick white paper, (3) lamp-black or charcoal powder, (4) gum Arabic, (5) clay, (6) dabber and (7) thick-haired brush. (Fig. 94.)



A B C D

FIG. 94. INSTRUMENTS FOR PREPARING ESTAMPAGES.
A. KNIFE; B. ROLLER; C THICK-HAIRED BRUSH; D. DABBER.

For portable inscriptions.—(1) water, (2) thick white paper, (3) printing ink, (4) soft roller, (5) dabber, (6) thick-haired brush.

Inscriptions on stone.—*Process A.*—1. First clean the stone thoroughly by washing to remove all the dust and other extraneous things from its surface. No force should be used; nor should any attempt be made to render a letter or sign clearer by chiselling, etc. The stone should not be inked or blackened because this injures the stone and makes it hard for use in future.

2. Take a sheet of thick paper, cut it to the size of the inscriped surface, and soak it in water for a while.

3. Wet the stone itself well with water before placing the sheet of paper on it.

4. Then place the sheet of paper on the stone as evenly as possible. It will stick to the stone as it is wet.

5. Take a thick-haired brush, or dabber and beat the paper smartly from the centre outwards so as to get rid of all air bubbles. Go on beating until the paper has taken the exact shape of the stone and followed every hollow, depression and inequality. It will crack and split in many places if the inscription is cut deeply or the inequalities of the surface are great, in which case a second, and, if necessary, a third sheet should be laid wet over the first and the beating repeated.

6. Do not try to pull the paper off the stone immediately after the beating process is over. Wait till it is dry when it will come off by itself.

7. When the beating process is over you will find that you have made a paper cast or stereotype of the original stone. This will, when dry, be quite hard and capable of resisiting considerable pressure.

8. Make a mixture of lamp-black or charcoal powder, gum and water, smear a dabber with the mixture and apply the dabber evenly on the paper, while it is still slightly damp, but not wet. The quantity of lamp-black mixture should be moderate as too much of it will blur the impressions, also if it is too thick it will rip the paper off the stone; and if the ink is too thin it will spoil the impression; too great or uneven pressure of the dabber also has the same effect. Then the raised parts will thus come out black and every depression of inequality will appear white. By this process minute details of the impression can be had.

9. If the sheets are not large enough to cover the whole stone, which will frequently be the case, repeat the above process over different parts of the stone, taking care that each sheet overlaps its neighbours so that its proper place can afterwards be easily determined.

10. Then the paper should be allowed to dry on the stone and can be rolled up for packing without fear.

11. Like every mechanical process the above requires a certain amount of practice before it can be done well. In order to ensure accuracy and to enable the reproducer to correct errors it is best always to take three impressions of every part of the stone.

Process B.—This is intended for taking impressions of small stone inscriptions when they are met with by chance and when there is no time to assemble the materials, required for taking impressions usually.

Get some quantity of clay which might be available locally and knead it well. Apply the well-kneaded clay over the cleaned stone to a thickness of about an inch, and allow it to dry.

When it is dry the clay will come off of itself, his is the negative of the impressions.

Now this negative is ready to be taken home. A positive from this can be prepared easily by means of plaster of Paris or clay itself.

Inscriptions on metal.—Inscribed copper-plates or other inscribed metal articles of no great weight should preferably be sent to the Madras Museum or the Government Epigraphist for India at Ootacamund, for study after which they will be returned to the owners immediately. In case the owner of the inscription objects to such a course, the following process should be followed :—

Wash the plate with soap and water. If this fails to remove the dirt the usual tamarind or lime juice method of cleaning may be tried to remove the thick encrustation, care always being taken to see that the pressure applied is even so as not to mar the forms of the letters of the inscriptions.

When the plate is dry, go over it with the soft roller smeared with printers' ink. A little ink should be poured on a piece of glass, and spread out and worked over with the roller until the latter is evenly coated before it is applied to the plate.

When this is done get your paper ready. Thick paper is the best. Cut it a little over the size of the plate. Damp the paper and place the inked plate on it and fold the paper over the back of the plate to prevent the paper from moving. If the plate is provided with a ring, a hole should be cut in the paper and a slit made for the ring to pass through.

Turn the plate face up, and, with a piece of hard smooth paper between, commence to beat the paper evenly with a stiff brush. The paper must be kept damp throughout by laying a folded damp piece of cloth over the parts you are not working on. Then remove the paper carefully, and allow it to dry. The points are reversed but can be read by holding their blackened faces against light.

After taking the impressions, the plate should be thoroughly cleaned with turpentine and then brushed with soap-water, so as to remove all traces of printing ink.*

Architecture —General.—Indian architecture is a fascinating subject owing to its great antiquity and variety of beautiful forms in which the examples of architecture are found. The originality of planning and dexterity of execution displayed in their works by the architects of ancient India compare very favourably with the best in the world. Above all just as in the other countries, in India also, her architectural productions reveal the genius of the people as well as their cultivated emotions.

The development of Indian architecture requires to be traced through the three major periods of Indian civilizations, viz., the prehistoric period, the Vedic period and the historical periods.

Prehistoric period.—Though the art of building has been known to Indians for a very long time, the most ancient examples of buildings met with are those unearthed at Mohenjo-Daro in Sind and Harappa in the Punjab, both now in Pakistan, the typical sites of the Harappa culture which flourished about the third millennium B.C. The buildings here are in complete ruins except for their basements. They are built of large burnt bricks. The highly scientific manner of construction revealed by the buildings is sufficient proof of the great heights to which the art of building was developed during this period. These buildings, except a few religious ones, are noted for their utilitarian character as exemplified by the famous bath and other buildings. This does not quite agree with the fact that architectural works of subsequent periods are predominently religious in character. Nor does it agree with the high religious awareness of the people of the Harappa culture itself as evidenced by the large number of cult objects, including the famous seal with the figure of Siva-Pasupati, discovered here.

Vedic period.—The Indus civilization having ended in a sudden and abrupt manner, about the beginning of the 2nd millennium B.C., there followed the period represented by the vast and wonderful literature called the Vedic literature. Very few remains of material culture representing this period have survived. The numerous references to several varieties of buildings met with in the Vedic literature have yet to be substantiated by actual remains. That perishable materials were used for construction seems to be one of the reasons for the absence of examples of buildings of this period. Anyway a fairly good idea of the form and meaning of both the secular and religious buildings of this period can be had from the references themselves especially in the texts called the *Sulba sutras*.

* The directions are adapted from the rules regarding decipherment of Indian inscriptions contained in Government of Madras, Public Department, G.O. No. 460, dated 15th June, 1907.

Post-Vedic period.—From about the 6th century, B.C. the history of architecture becomes clear. It appeares that for a long time wood and other perishable materials were employed for building houses and shrines, as for instance the Mauryan palace at Pataliputra. Isolated cases of rubble building and stupas built of bricks are known, e.g., the walls of the fortress of Rajagriha and the stupa of Piprahwa which belonged to pre-Mauryan times. But stone was largely employed in buildings only from the time of Asoka from which period, the development of Indian architecture can be traced with little difficulty. Among the large number of examples of buildings, a great majority are religious in character; examples of secular buildings are few and far between.

From the time of Asoka to about the 4th century A.D. Buddhism was very popular. Hence a large number of Buddhist shrines, etc., belonging to this period have survived to the present day. There was buildings belonging to other religions also but they were few. Later on Hinduism became very popular and its protoganists, in their zeal to get rid of Buddhism, adopted various methods of propaganda by which the Buddhists popularised Buddhism. One of the important methods was communal worship in a shrine. So the Hindus began building shrines and temples not only loftier and grander in their appearance but also peopled them with larger number of images of gods and goddesses than in the Buddhist shrines. Though Buddhism was thus overwhelmed by Hinduism, Jainism continued to exist side by side with Hinduism and the Jains followed suit by building magnificient temples. When, in Northern India and the Deccan, the Muslims began to rule, they built mosques, tombs and palaces in a style which is called Saracenic. The chief characteristics of this style of architecture are the arch, the dome, the minar, the mosaic and the calligraphic patterns. Below, a brief outline of the development of Indian architecture during the historical periods is given.

Main categories of buildings.—The religious bulidings of ancient India fall under the following three heads, viz., (1) the Stupas (2) the rock-cut caves and (3) the temples. Of these the examples of stupas and rock-cut caves are available from a very early period, and they fell into disuse about the 9th or 10th century A.D. It may, however, be remembered that wherever Budhism is still followed, the practice of building stupas continues, for instance in Ceylon, Burma and Tibet. Examples of temples are available only from about 200 B.C., but the practice of building temples continues to this day.

Stupas.—The stupa was, to start with, but a burial mound or tumulus, enclosing within it the relics of enlightened souls, great seers or famous monarchs. The veneration of such a structure was common amongst the masses. So, when Buddhism and Jainism which were popular with the masses got established, the building of stupas over the relics of the Buddha or his disciples and over those of the Jaina seers, and offering worship to them became an

important practice among the followers of these faiths. This practice was, however, more perdominant amongst the Buddhists than amongst the Jains. Owing to this fact Buddhist stupas have been discovered in large numbers not only in different parts of India but also in Ceylon, Burma, Indonesia and China where also this religion spread.

Kinds of Stupas.—There are three kinds of stupas, namely *sariraka stupas* which are so called because they enshrine the bodily relics of the founder or saints of the religion; *paribhogika* stupas which are erected over the articles such as the begging bowl or staff of the founder; and *pariyatrika* stupas so called because they are put up on the spots hallowed by the visits of the founder or his disciples.

Form of Stupas.—The stupa in its simplest form consists of a hemispherical dome surmounted by a square railing called harmika, the latter enclosing one or more shafts of the crowning umbrella; one or more cylindrical or square plinths supporting the dome and one or more railings enclosing perambulatory passages (Fig. 95).

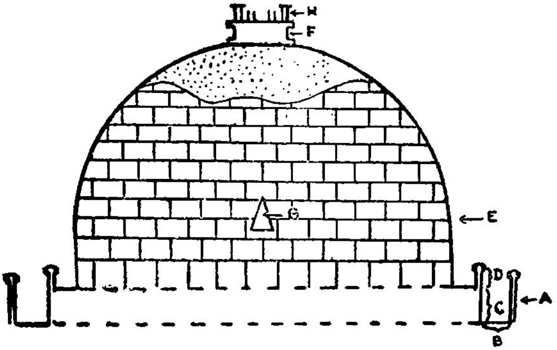


FIG. 95. VERTICAL SECTION OF STUPA.

Generally the stupas of earlier periods were hemispherical in shape with a low base. But as time passed on the stupas began to assume an increasingly cylindrical form with the drum further developed. In the case of the later stupas the decorative elements came to predominate and the drums and umbrellas were multiplied. Though this was the unit commonly met with, owing to local contributions, the construction of the stupas in the different parts of India and in the different countries where the religion went came to possess certain distinguishing features.

Special features of the Stupas of different regions of India.—Thus the special features of the North Indian stupas are the gateways with sculptural decorations on them, and those of the North-West Indian stupas are the multiple square bases or drums with trefoil-arched niches containing Buddhist images and with no railing on

gateway. The features of the South Indian stupas (Pl. III) are the lion pillars at the gateways and the five *ayaka* pillars erected on each of the projections at the four cardinal points. The characteristics of the Ceylon stupas are the bell-shaped dome, the wahalkadas or architectural projections at the four cardinal points, the rows of stone pillars said to be intended for carrying a roof over the stupa, the moon-stones and the Yakshas carrying a *purnaghata*. The features of the Burma stupas are the tapering drum with the series of crowning umbrellas merging with it and the covered circumambulatory passage. Similarly the Buddhist stupas of Tibet and China have distinctive features. Besides these there are some unique stupas such as the stupa at Nandangarh and the stupa at Borobudur in Java.

History of the Stupas.—The most ancient of the stupas is the one discovered at Piprahwa in the former United Provinces. From the palaeography of an inscription found in it and the large sized bricks employed in its construction, it is dated to pre-Asokan times. Having been built of perishable materials more examples of stupas of the period have not survived. But it is more true to say that only after Asoka's time did the art come to be practised on a large scale as he, with the characteristic zeal of a new convert, strove hard to spread Buddhism far and wide. Asoka is said to have built 84,000 stupas over relics of the Buddha which he got by demolishing the seven out of eight original stupas which contained the original relics of the Buddha. Although we have other corroborative evidence to prove this, no remains of such large number of stupas have come down. Asoka is said to have built the first stupas at Sanchi and Saranath. The Asokan stupa at Sanchi was covered with stone slabs, in the 2nd century B.C., and at about the close of the first century B.C., were added the lavishly carved gateways. Among other important stupas of North India, the one that stood at Bharhut in Central India was remarkable for the wealth of sculptural decorations on all its parts. The remains of this stupa are now housed in the Indian Museum, Calcutta.

A large number of stupas were erected during the period from the 2nd century B.C., to the 3rd century A.D., in South-East India in the Krishna–Godavari region. They included the stupas of Amaravathi; Nagarjunakonda, Bhttiprolu and Jaggayyapeta. They are all remarkable for the marble sculptures that adorned them and for the wealth of information contained in the inscriptions. The Amaravati stupa was specially noted for the magnificient marble sculptures, a group of which is housed in the Madras Museum, while another important group is to be found in the British Museum London.

A number of stupas were discovered in the North-West of India at such places as Taxila, Manikyala, Takhti-i-bahi and Charsada. They are all executed with corinthian pillars. An exceptionally large stupa discovered at Shahji-ki-dheri near Peshawar contained the famous relic-casket of Kanishka.

Brick stupas were constructed during the 5th-6th centuries A.D., both in the plains of Sind and in North India. They are all ornamented in the typical Gupta style.

In this connections something has to be said of the rock-cut stupas in the rock-cut caves of Western India. These are but replicas of structural examples and closely follow their development. Finally, however, having attained an elongated from decorated with a wealth of details these rock-cut stupas became a kind of shrine enclosing a huge figure of standing Buddha or Buddha seated in the European fashion.

Rock-cut caves.—Early caves.—As in the case of the stupas, the earliest rock-cut caves also date from the time of Asoka. But these caves of the 3rd century B.C. which are excavated in the Barabar and Nagarjuni hills of Bihar have the characteristic Mauryan polish in their interior and their date is definitely known from the inscriptions on them. Further, the figures of elephants carved in relief on the tympanum of the facade of the Lomas Rishi cave are extremely good examples of plstic art of the period. Moreover, these tiny caves dedicated to the wandering ascetics called the Ajivikas, appear to have been based on the models of grottoes dating from the 6th and 5th centuries B.C. of Persipolis, in Persia proving that Asokan art and architecture were influenced by the ideals of Persian art.

Types of caves.—Of the Buddhist caves there are two types, namely, the *viharas* (monasteries) and the *chaitya*-halls. The Hindu and Jaina rock-cut caves are simple caves with niches on the walls containing powerful carvings of gods and goddesses. The earlier Buddhist caves are unmistakable copies in rock of structural works in less permanent materials such as wood. This is evidenced not only by the adoption of several designs and devices characteristic of wooden structures but also by the presence of actual wooden beams, etc., in the roof and other parts of the cave.

Chaitya-halls.—Of the two types of Buddhist caves the *chaitya* hall is more important and consists of a vaulted congregation-hall, with an apsidal back. It has a rock-hewn stupa. Rows of pillars divide the cave into a nave and side-aisles. The most important and carefully worked part is the facade with doorways below and horse-shoe shaped window above, which lets in light and air. The most important examples of the *chaitya*-halls of the early phase are those at Bhaja, Ajanta (cave No. 9) and Karle (Poona District). The early *chaitya*-halls are characterised by restrained ornamentation, pronounced tendency to imitate wooden models sometimes actual wooden girders being employed, and the slow introduction of sculptures on the various parts particularly on tops of pillars. Of all the *chaitya*-halls the one at Karle which dates from the 1st century B.C. is the most magnificent. All the early examples of rock-cut caves belong to the Hinayana sect of Buddhism.

Viharas.—The monasteries of the earlier phase are based on ordinary dwellings consisting of rooms for monks around a court-yard. But the monasteries of the middle phase are dwelling-*cum*-shrine caves containing not only a shrine chamber with a pillared assembly hall in front but also having niches on the walls with Buddhist images carved in them. Furthermore, as time went on, instead of simple single-storeyed monasteries there were excavated caves of enormous size with two and three storeys with a large number of pillars also in their plan. Brahminical caves of this phase are met with in the Krishna valley although no example of Jain cave representing this phase has been brought to notice.

Caves of Western India.—The rock-cut architecture which began on such modest scale in the 3rd century B.C., however, developed into " a powerful and popular architectural mode " during subsequent periods. This is proved by over a thousand caves scattered throughout the country. But a great majority of them occur in the Western Ghats, and in the Bombay Province, the rock of the Ghats being especially suited for the excavation of the caves. There are three phases in this type of architecture, the first phase dating from 200 B.C. to 300 A.D., the second from the 5th century A.D. to 7th century A.D. and the third phase from the 7th to 10th century A.D. Examples of caves of these groups are found in the Western Ghats at Bhaja, Bedsa, Junnar and Karle; Elephanta and Kaneri near Bombay; and Nasik, Ajanta and Ellora in the Hyderabad state. There are thirty caves at Ajanta dating from the 2nd century B.C. to the 7th century A.D. and these are all Buddhist. There are thirty-four caves dating from the 5th to 8th century at Ellora which include caves devoted to Buddhism followed by those of Brahmanism and Jainism.

Caves of Kalinga.—Comtemporary with the earliest caves mentioned above are the caves in the two hills namely Khandagiri and Udayagiri in Orissa, which are devoted to Jainism. There are thirty-five of them, but only a few of them are of any consequence. The workmanship of these caves is rather archaic and they are characterised by fanciful pillar brackets, animals on pilasters put back to back and riders on griffins. The Rani Gumpha cave, the Ganesa Gumpha and a few other caves contain friezes of sculptures depicting scenes from a Jaina story

Later caves of Ajanta and other places.—The middle phase of rock-cut architecture is exemplified by a large number of excavations scattered all over the country including the South. Still a great majority of them are found in the Western Ghats, particularly at Ajanta in Hyderabad and Bagh in Central India. The note-worthy features of these caves are the complete elimination of wood constructions and imitations thereof and the introduction of images of the Buddha and Buddhist pantheon. The pillars and *chaitya*-window above the doorway show greater developments. The shafts of the pillars are ornately worked with cushion-like capitals and massive brackets the most important difference betwen these later

Buddhist caves and the earlier ones being the introduction of the Buddha image in the rock-cut stupa itself, which has now assumed an elongated form its finial touching the roof above. Of the examples at Ajanta, the cave No. 26, is noteworthy The latest, *chaitya*-hall of this phase is the Visvakarma cave which is the best known of the rock-cut caves at Ellora in the Hyderabad State. Although not decorated with so much of sculptures as in the caves at Ajanta, the Visvakarma cave of Ellora is distinguished by its novel chaitya-window design.

Latest caves.—Examples of the last phase of rock-cut architecture exist at Mahabilipuram, Ellora, Elephanta and Jogesvari. Their date falls between the seventh and ninth centuries. The earlier caves are Brahminical, while the later ones are of Jainism. Of the Brahminical caves there are three or four types, namely simple monstery-like caves, for example the three-storeyed Dasavatara cave at Ellora with sculptures representing scenes from Hindu mythology; the shrine separated from the halls, for example the Dhumar Lena cave at Ellora and the caves at Elephanta and Jogesvari which are noteworthy for their elegant pillars with cushion capital and for the interesting way of getting the interior lighted through their three portals; and lastly the rock-hewn copy of an actual structural temple, for example the wonderful Kailasa at Ellora and the group of monolithic shrines at Mahabilipuram the former dating from the 8th and the latter from the 7th century A.D. These last works impress the visitors by the grandeur of conception, magnitude of excavation, and the rich sculptural embellishment.

The last examples of this phase are the Indra Sabha and Jagannatha Sabha caves at Ellora dedicated to Jainism. They date from the 9th and 10th centuries. They are distinguished by their rich carvings and beautiful pillars. But here in the caves are noticed the signs of decadence of this style of architecture.

Temples—Early temples—By far the most interesting class of Indian architecture is that of the temples built of bricks or blocks of stone. It had its roots in the prehistoric periods and the Vedic period. But actual examples of this class also date from the Asokan time. Not many examples of temples have come down representing the period from the 3rd century B.C. to the 4th or 5th century A.D Belonging to the Mauryan time are the foundations of an apsidal temple met with at Sanchi. To the second century B.C. or so belong the ruins of two Bhagavata temples of uncertain plan and design, one from Nagari in Udaipur and the other from Besnagar in Gwalior. There have survived temples in an Indo-Greek style characterised by the Ionic pillars and dating from the end of 2nd century B.C. in places around Taxila. Apsidal temples of the first three centuries of the Christian era are known, two from Taxila and one from Nagarjunikonda. Besides these actual examples, a number of shrines of a variety of form and design appear to have existed at this period, remains of which have not survived owing

probably to the perishable materials employed in their construction. A good deal of information about these is available in the epic, puranic and other kinds of literary works of this period. More significant than these are the figures of temples carved in relief in the sculptures such as those of Bharhut (2nd century B.C.) Sanchi (1st century B.C.) and of Amaravati (2nd century A.D.).

Beginnings of Sikhara temples.—In North India, from the time of the Guptas, the temples came to be built in an increasing number. But in South India, however, the art of building temples in more permanent materials began to be practised widely only from the 7th century A.D., although temples built of perishable materials, which therefore, could not survive, should have existed before that time as evidenced not only by a volume of literary references in the early Sangam works in Tamil language but also by the more authentic evidence of an inscription of Mahendravarman I Pallava (600-630 A.D.) wherein it is stated that he built a temple to the Hindu Trinity in stone avoiding the use of wood, brick, metal and mortar. Beginning with small shrines of little consequence during the Gupta times in the North, in the Kadamba period in the Deccan and in the Pallava period in the far South, temple architecture was soon to grow into a system of building quite unequalled for the variegated beauty of its forms, decorative elements, both pictorial and sculptural and stupendous size. This class of religious structures has had a continuous development and is still in vogue in many parts of the country. Owing, however, to variations of details introduced into the works by architects of different localities, the examples of this class belonging to the different periods and places of India differ in their forms and decorations.

Three ancient styles of temple architecture.—Thus the temples fall into three major groups each having one or more sub-groups. They are the *Nagara* (or northern), the *Vesara* (or the Deccani) and the *Dravida* (or the South Indian). Besides them, there are two other groups of temples namely the Kadamba and the Kerala temples which are confined only to the small territories of Konkan and Kerala both in the West Coast of India. The Kadamba temples are easily identified by the sanctum roofed by a stepped pyramid (Fig. 96) each of the steps sometimes being decorated with a series of projections. The Kerala temples are akin to the temples of Nepal not only in their wooden construction but also in their pitched roofs a device calculated to withstand the torrential rain that falls in these areas.

Plans of temples. Before proceeding to observe the development of the three major groups of temples, a word about the different kinds of plans employed in their construction may be said. There are temples with (a) a circular plan, e.g., a number of them are found in Kerala; (b) temples with square plan which are more commonly met with in all parts of the country; (c) temples with an apsidal plan, e.g., the early temples from Sanchi, Taxila, etc., noticed already, the temples at Ter and Chezarla of the 4th or 5th

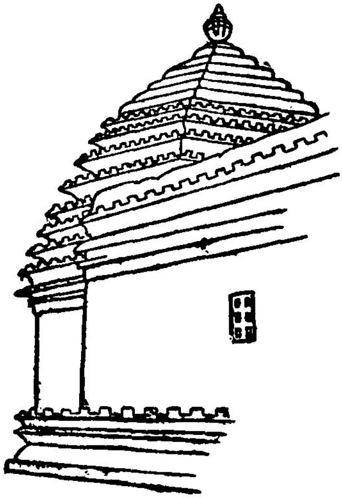


FIG. 96. KADAMABA TEMPLE

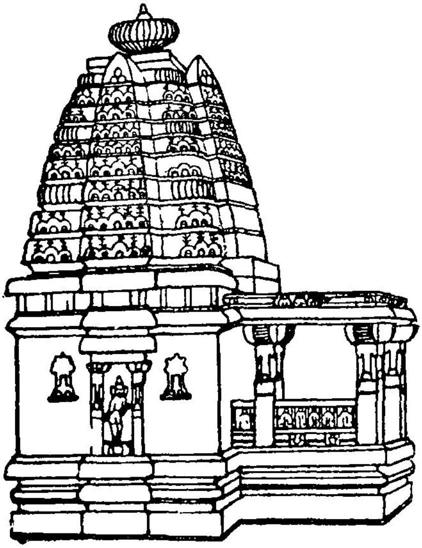


FIG. 97. NAGARA TEMPLE

century A.D., the Durga temple at Aihole of the 6th or 7th century A.D. the Sahadeva Ratha at Mahabalipuram of the 7th century A.D. and a large number of temples of the early Chola period met with in the Deccan and the South; (*d*) the temples with rectangular plan, e.g., the bas-relief representation of Indra Sabha in the Bharhut sculptures of the 2nd century B.C., the representation of a shrine in the sculptures from Jaggayapeta also 2nd centuary B.C., the Bhima Ratha shrine of Mahabalipuram of the 7th century A.D., the Vital Deul of Bhubanesvar of the 8th century A.D., the Teli-ka-Mandir of Jaipur of the 15th century A.D. and gopuras of all the later temples of South India; and (*e*) temples with a multi-angled plan: e.g., the Hoysala temples of Somanathpur and Belur in the Mysore State dating from the 12th to 14th century A.D.

Survey of Temples in Different Styles—Nagara style.—The earliest temples in the Nagara style consist of a flat-roofed cubical cellar with a pillared portico in front. The temple No. 40 at Sanchi is an example of this variety and it dates from the 5th century A.D. Soon after, a superstructure of a distinctive type was added to the top of the cell. This superstructure possessed the characteristics such as a curvinlinear form, an *amalaka* finial and *amalaka* slab at regular intervals at the corners to indicate the storeys (Fig. 97). The earliest example for this variety is the temple at Deogarh in Jhansi District, dated to the beginning of the 6th century A.D. This kind of temple is further interesting in that it is raised on a high plinth with flights of steps. The further development of this style is seen in the groups of temples at Bhubanesvar and Khajuraho, in Rajasthan and in the Vindhya Pradesh. From the forms of their superstructure or tower they can be classified as follows: Curvilinear type, the temples of Bhubanesvar; *merusringa* type, the temples of Khajuraho tower with multiple miniature towers on its body as in the temples of Rajasthan; and the temples in the Vindhya Pradesh especially those of the Hamadpanti type towers with broad ribbon-like projections from top to bottom on their four sides.

Bhubanesvar temples.—Of the group of temples at Bhubanesvar the earliest is Parasuramesvara temple which is dated to about 7th century A.D. It has the cimplest of the curvilinear type of towers and a peculiar *mukhamandapa* or *Jagmohan* in front. But as time went on the *Natamandapa* and *Bhogamandapa* were added in front of the Jagmohan and the whole was enclosed in a wall with a *torana* or gateway. Fine examples of the developed type are the Raja Rani and Lingaraj temples of the 11th century A.D. at Bhubanesvar, the Sun temple at Konarak and Jagannath temple at Puri of a later period. The Sun temple is further noteworthy for the introduction of gigantic wheels on its sides and the colossal horses supposed to draw the chariot-like temple of the Sun God. Although the temples of Northern style are generally astylar, i.e., built with a minimum of pillars, the latest temples have a number of pillars in their halls.

Temples at Khajuraho.—The temples at Khajuraho which include Hindu and Jaina shrines and dated to the 11th and 12th centuries A.D. are noteworthy for their multiple *sikharas*, the covered perambulatory passage, the porticos with the peculiar sloping seats, the *mandapas* with richly carved ceilings, the wealth of ornamental mouldings and highly realistic sculptures on the exterior of the walls. The famous example of this type is the Kandariya Mahadeo temple.

Jain temples.—The temples of the Rajasthan area are remarkable for their beautifully designed pillared porticos, and the Hemadpanti temples of the western Vindhya Pradesh for their highly interesting towers. This note will not be complete if no mention is made of the Jain temples of Gujarat and Kathiawar. The typical examples of the group are found at Satrunjaya and Mount Abu. These are called the Dilwaras. There are only a few towers in these temples, and in their place a variety of squat domes are employed. These are said to have been employed practically as a protection against the iconoclastic fury of the Muhammadan invaders. Though the general view of these temples will not be very impressive they are unparalleled for the richness and delicate beauty of the carvings of their interiors especially of the pillars and ceilings. The grandeur of the interior of these shrines is very much enhanced by the material, white marble, employed in their construction. The famous examples of this group of Jaina temples are the Vimalsha and the Tejpala temples of the 11th to 13th renturies A.D. at Mount Abu.

Deccani Style.—Coming to the temples in the Deccan, there is noticeable in them a tendency for a mixture of elements of northern and southern styles of construction. At first examples in each style were built side by side separately but later on the fusion of the elements of each style came to be effected in one and the same shrine. In the Deccan, however, the temple building is known for a long time and the earliest of the temples of this region is the famous Lad Khan temple which is unique in several respects. Its pillars are square and massive, its sanctum is not surrounded by an aisle enabling the devotees to go round, and its roofing is done by means of stone slabs in the " tile roofing " fashion. A century or so later than the Lad-Khan temple was built the apsidal Durga temple. It has also the massiveness and other primitive features of construction found in the Lad Khan temple. But here fore the first time is met with a northern tower in its simplest form over the sanctum. Further the sculptural decorations of this temple are worthy of special mention. Belonging to the early Chalukyan times and dating from the end of the 6th century A.D. are the Mahakutesvara and the Hucchimalligudi temples at Aihole both of them in the Dravidian style, in which the tower is constructed in a pyramidal fashion with storeys rising up in a diminishing series each of them containing replicas of shrines. Temples in northern style occur

side by side with temples in southern style at Pattadakal, some of them dating from the 8th century. But from about the 9th century the tendency for fusing the elements of the curvilinear tower with those of the pronouncedly southern pyramidal tower where horizontal lines predominate, has begun to appear with the result that the temples from this period began to have a plan with more angles than four. Further, as time went on a temple built in this style consisted of three temples joined by a closed verandah (Fig. 98).

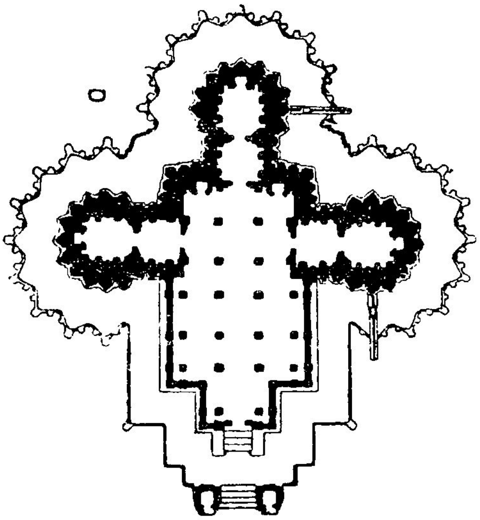


FIG. 98. STAR-SHAPED TEMPLE PLAN.

All these were erected over a plinth which closely followed the angles of the *vimanas* themselves. The famous examples of this star-shaped style are the ones built during the period of the Hoysalas of Dvarasamudram, and they include the temples at Belur, Halebid and Somanathpur in the Mysore State. These temples are characterised by minutely and delicately carved figure sculptures and pillars of a variety of forms. The lathe-turned pillars with high lustrous polish of the Jaina temples are specially noteworthy.

Tamilian Style.—The story of the temple architecture of the Tamilian (Dravidian) style remains to be told. As has already been said examples of temples are available only from the time of the Pallavas in the southern-most part of India, the earlier temples of this region, if any existed, not having survived owing to various reasons. The examples of the Dravidian style are found scattered throughout the undivided Madras Province as well as in some parts

of Travancore and Mysore States and the Deccan. The development of the architecture in this style being continued unbroken till this day, there are naturally differences between the temples of one period and those of the other. Accordingly the temples of South India can be classified as follows: the temples of the Pallava, the Chola, the Vijayanagar, the Pandya, the Nayak and the Modern periods. In each period, a significant addition to the temple complex was made and a distinctive development in the decorative details and motifs is noticed.

Pallava temples.—Building temples in stone being an innovation introduced into South India by the great art-minded Mahendravarman of the Pallava dynasty, temples of his period show clearly the marks of archaism such as massive square pillars and *kudus* enclosing human heads on the cornices. And all his temples are only rock-cut caves which are scattered throughout the country over which he held sway. Thus Mahendravarman's cave temples are found at Pallavaram near Madras, Dalavanur near Gingee, Tiruchirappalli and Sittannavasal near Pudukkottai. Architecture reached an interesting and significant stage of development during the time of Narasimhavarman I Pallava, the son and successor of Mahendravarman I. The noble little monolithic shrines of Mahabalipuram were hewn out of a long boulder by the highly talented Pallava architects who were inspired to create out of shapeless masses of rock, works of great beauty and of everlasting interest by the art-minded son of an art-minded father. The creative genius of the people who were responsible for these monolithic shrines is clearly brought out by the variety of beautiful forms. Each one of the five shrines is an interesting study by itself. The so-called Draupadi Ratha (the Durga shrine) has the simplest form with a thatched hut-like superstructure. The Arjuna Ratha has a more developed form and is clearly the predecessor of later magnificient examples of temple *vimanas*. The Sahadeva Ratha is interesting for its apsidal plan. The Bhima Ratha has a wagon-shape which anticipates the stupendous gopuras of later periods. The most interesting of the shrines is the Dharmaraja Ratha which has three storeys, each storey being separate from the other. In these temples the pillars assume a slender form with seated lions at their bases. Besides these monoliths, Narasimhavarman also caused the excavation of a few rock-cut caves which also have the developed pillar. Excavating temples was continued during the reigns of Narasimhavarman's two immediate successors also. But a bold step forward was taken in the art of building by Rajasimha, the great-grandson of Narasimhavarman I who began the practice of building structural temples and out came from worked slabs of stone the magnificient Jalasayanesvara temple popularly known as the Shore Temple which has remained through the centuries, the cynosure of both mariners on the sea and pilgrims to Mahabalipuram. The characteristics of the Shore Temple are pillars with rampant lions, the prismatic *linga* in the sanctum facing the sea, and the compound

wall surmounted by couchant bulls. Having met with a good success in this novel experiment in the art of building, the great monarch Rajasimha caused similar structural temples at Panamalai in the South Arcot district and at Kancheepuram. The Kailasanatha temple at Kanchi built by him is justly famous for its magnificient design, beauty of decoration, wealth of powerful *puranic* sculptures and grand tower over the sanctum. Here the pillar with rampant lion at its base is conspicuous. Other special features of this temple are the subsidiary shrines lining the interior face of the compound wall and the small stunted tower over the gateway which is the most ancient example of a gateway tower. At a later period a hall was added to this temple in front of the sanctum, which is also a noval feature having great potentialities to develop into halls of hundred and thousand pillars of later periods.

A few years later and during the reign of Rajasimha's successor Nandivarman II, the Vaikunthaperumal temple at Kanchi was built. The central shrine has three distinctively demarcated storeys like the Dharmaraja Ratha at Mahablipuram. It is enclosed by a wall and on the inner side of this wall is put up a verandah on a raised platform. The pillars of this temple show seated lions at their bases, and the *palagai* and cushion-capital at their tops.

Chola temples.— The norm of the temple unit established by these examples was continued till about the end of the 11th century. But in the meantime, due to causes which are to be explained elsewhere, a large number of temples with an apsidal plan came to be built. The late Pallava temple in this style at Tiruttani is an early example. But a great majority of them belong to the period between 850 A.D. and 1100 A.D. The building of temples on this plan was discontinued after that date again due to causes unknown. The culmination of the type initiated by Rajasimha Pallava was reached in the Brihadisvara temple at Tanjore built by the great Rajaraja Chola. The noteworthy features of this temple are the larger, now more interesting pillars, simple mouldings of the basement, the large *mahamandapa* and the much more pronounced tower over the gateways. Till this time the temple unit remained the same, namely, the sanctum, *antarala*, *mahamandapa* and *nandi* pavilion, all these surrounded by a high wall with its entrance surmounted by a tower of stunted dimensions. A few additions such as the separate shrine for Chandikesvara and the second gateway with tower are seen in the Brihadisvara temple. But in the temple at Gangaikondacholapuram built by Rajendra Chola I one more significant addition has been made in the form of a separate shrine for the goddess. Up to this time no separate shrines to the goddess, either in a Vishnu temple or in a Siva temple, were found although there existed independent shrines for goddesses of a terrific nature such as Durga and Kali. Subsequent to the 11th century till the end of

the Chola period no more significant additions have been made to the temple unit except the elaboration of the pillared *mandapa* and the decorative features of the pillars. A beautiful example of mandapam in the form of a chariot is found in the temple at Darapuram which belongs to the 12th century A.D.

Architecture during the Vijayanagar period.—It is only in the Vijayanagar period that a great effort was made to embellish the already existing temples of great sanctity with more elaborately wrought halls and gateway towers. The simple fluted pillars with highly restrained decorations of the earlier temples have been substituted by huge monolithic pillars carved very minutely and with figures of lion trampling an elephant, horseman at hunt, etc., of exquisite workmanship. The most famous example of this kind of *mandapa* is the Kalyanamandapa at Vellore of the 15th century A.D. Further, a lot of time and labour was spent in the construction of elaborate gateway towers which from this period onwards began to dominate the entire temple complex and made the central shrine dwindle into insignificance. A more important development than all these is the introduction of the feature of erecting more than one compound wall around a temple, the famous example being the temple at Srirangam. It is in the vacant court-yards between the central shrine and the first wall and between the walls themselves that the above mentioned elaborately worked pillared halls were erected. A significant development observable in the corbels at the top of the pillars is the foliage motif. Monumental examples of the towers of Vijayanagar period are those found at Tiruvannamalai, Chidambaram and Hampi. Erecting similar towers was also the practice with the kings of the Pandyan dynasty.

Nayak contribution to Architecture.—During the period of the Nayaks of Madura a novel addition was made to the temple. It is the erection of corridors which is exemplified by the Pudu Mandapam at Madura. The tradition of building gopuras was also continued with great vigour. Further the corbels of the pillars of this period show at their ends a plantain flower-like motif. Another good example of an early corridor is met with in the Nellayappar temple at Tirunelveli.

Architecture of the modern period.—The last great step taken by the architects of the Tamil country was in the direction of integrating and unifying all the different parts of a temple, such as the central shrine, *mandapas* and the *prakaras*, which till now remained disjointed, into an integrated whole. The way for achieving this was paved by the innovation of corridor building during the Nayak period in the 16th and 17th centuries A.D. The latest achievement consists in covering the spaces between the walls by a stone roof and introducing into the spaces the corridors all round. The finest example of this development is found in the temple at Ramesvaram in the Ramanathapuram district.

Indo-Islamic Architecture *.—The contributions of the Muslims to the artistic wealth of India are considerable. Their achievements in the field of architecture are marvellous. Some of the examples of the art of buildings produced under the aegis of Muslim rulers rank among the best of their kind in the world. Though the Muslim incursions into India date from the beginning of the 8th century A.D. the Indo-Islamic works of art date from only the 12th-13th century A.D. after the firm establishment of Muslim rule in Delhi.

From long before this period the Muslims in other parts of the world have produced works of art and architecture. But what was produced by them in India has a flavour of its own. Especially in the field of architecture, the Muslims who permanently settled in North India got several new ideas from the indigenous architects, e.g., the brackets for supports. They had discarded many an element of Islamic architecture of Persia and other places. The result of this judicious combination was Islamic architecture of Indian type. The chief characteristics of this hybrid architecture are, use of concrete and mortar, spanning big spaces by arches, covering large areas by domes, beautifying by minarets, etc. Their decorations included beautiful geometric devices, fine calligraphy, gilding and mosaics.

Since the Muslims were concentrated in North India and spread to a few places in the Deccan, their monuments exist only in these places. In South India examples of Indo-Islamic architecture do not exist except for a few insignificant imitations. But, in several secular buildings belonging to the late Vijayanagara and Modern periods a number of elements of Indo-Islamic architecture have found a place owing to their special architectural and aesthetic qualities.

Delhi being the capital of India during almost the whole of the period of the Muslim rule (nearly seven hundred years) it has a number of splendid monuments belonging to this period. Early specimens of architecture show Hindu influences to a large extent e.g., Quwwatu'l-Islam (1191 A.D.), the tomb of Sultan Ghari built by Emperor Iltumish for his eldest son (1231-32 A.D.), and the tomb of Iltumish (1235 A.D.)

The Khalji period (1290-1320 A.D.).—During this period the arches and other domed constructions began to be built on true scientific basis. The earliest mosque built entirely according to Islamic conceptions is the Jama'at Khana Masjid at the tomb of Hazrat Nizamu'd-Din Auliya, Delhi. A notable specimen of architecture of this period is the 'Alai Darwaza'. Generally the monuments of this period are noted for their rich ornamentation and elaboration of details

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* Summary of the chapter with the same title occurring in the book on *Archaeology in India*.

The Tughluq period (1320-1413 A.D.).—In the monuments built during this period a puritanical simplicity is noticeable. Special features of the architecture of this period are multiplicity of small domes, battered walls and squinch arches. Important examples of this period are the fort of Tughluqabad and the tomb of Tughluq Shah (1321–25), the fortress of 'Adilabad and the Kotla Firuz Shah.

The Sayyid period (1414–1444 A.D.).—Under Sayyid and Lodi kings the austerity of the monuments of the previous period was to some extent removed, but not completely. The tombs belonging to the 15th and 16th centuries show more elevated domes, pinnacles at the angles of the drum and pillared kiosks in place of low subsidiary domes. Enamelled tile-decoration and lotus finials are some of the other characteristics.

The Lodi period (1451–1526 A.D.).—The most significant contribution of this period is the double dome which is probably Syrian in origin. The tomb of Sikandar Shah Lodi (1517–18) is a good example of this style. The Moth-Ki-Masjid is, however, the best specimen of this style.

Provincial styles.—During the period from 13th to 16th century A.D. when Muslim rule spread to various parts of India, several provincial styles of architecture also sprang up, such as Multan, Bengal, Gujarat, Malwa, Jaunpur, Kashmir and the Deccan. Of these, the Deccan style is particularly important because of its variety and extent. There are the following substyles under its Bahmani style (1347–1527 A.D.), examples of which are found at Gulbarga and Bidar the successive capitals of the dynasty; Adil Shahi style (1490–1686 A.D.), specimens of which are found mainly at Bijapur, the Gol Gumbaz which is the tomb of Muhammad Ádil Shah (1627–57) being one of the largest buildings in India and which shows a beautiful projecting cornice and the unique method of supporting the dome by a combination of intersecting arches, unknown to Indian architects till then; Faruqui style (1382–1601 A.D.); Barid Shahi style (1487–1619 A.D.) examples of which are found at Bidar, the finest of them being the tomb of 'Ali Barid; and Qutb Shahi style (1512-1687), tombs, etc., of which are found at Golconda.

Mughal Architecture.—The Mughal period in Indian history is a remarkable one especially in regard to Islamic architecture. Owing to disturbed political conditions during Babur's and Humayun's times no significant buildings were built. But the tomb of Humayun, which is a specimen of early Mughal style was built by his devoted wife; and it is interesting to note that it served as the model for the world famous Taj. Its importance lies in the fact that elements of Persian and Indian styles of architecture have been blended in it successfully.

The Suri style (1540–1555 A.D.).—Sher Shah and his successors who ruled during this period built a few interesting buildings at Delhi and in Bihar. In view of their restrained character these buildings are said to commence the era of Mughal architecture. The Sher Shah's mosque (1541 A.D.) built in the Purana Qila at Delhi is a beautiful monument. The octagonal tomb of Sher Shah a Sahasram in the Shahabad District of Bihar is considered to be a gem.

Akbar's period (1556–1605 A.D.).—The highly cultured emperor Akbar was responsible for innumerable buildings of architectural interest scattered at such places as Agra and Allahabad. Those found at his new capital of Fatehpur Sikri are specially interesting. He borrowed very little from other countries, used red sandstone for his buildings with a sprinkling of white marble, employed trabeate order, made pillar-shafts of many sides, etc. Of the several magnificient buildings at Fatehpur Sikri, the Jami Masjid, and the Diwan-i-khas are important. The latter building has a beautiful central column supporting a circular platform. The Agra Fort is an achievement of Akbar's time.

Jahangir's period (1605–1627 A.D.).—Though fine arts in general were encouraged during this period, architectural achievements are few. Nevertheless the tomb of Akbar (1613–14) may be said to be a fine example where gardens are introduced with good effect. Another building of some importance is the tomb of Itima du'd—Daulah at Agra, which marks the stage of transition between Akbar and Shah Jahan.

Shah Jahan's period (1627–1658 A.D.).—This emperor was for elegance and charm while his father and grandfather were for exuberance and vigour. His buildings are of white marble, show cusped arches, have bulbous domes, possess pillars with foliated bases, etc., and are beautifully decorated with fine scroll work and flowers produced by inlaying semi-precious stones on marbale. Buildings of his period are found at Agra, Delhi, Lahore, Srinagar and Ajmeer. Of these the Taj Mahal at Agra is justly famous for its beauty and is said to be one of the finest buildings of the world. It is now known to have been designed by Ustad Ahmad of Lahore, not by a foreigner as was believed till a few decades ago. Its grace and loveliness are chiefly due to the chaste white marble and its ethereal splendour is a fitting tribute to the lady of the Taj. The other important specimen of architecture is the Moti Masjid (the Pearl Mosque) in the Agra Fort. Shah Jahan shifted his capital from Agra to Delhi where he built the famous Red Fort and the Jami Masjid. There are a number of buildings within the Red Fort of which the Diwan-i-khas is typical.

Post-Shah Jahan period (1658–1858 A.D.).—Decadence set in in every branch of art, particularly in architecture. The Pearl Mosque or Moti Masjid built bv Aurangazeb in the Delhi Fort is a instance in point.

Sculpture.—As in the case of architecture the most ancient examples of the art of sculpture also date from the period of the Indus civilization. That the art was highly developed during this period is amply borne out by specimens executed by the Indus sculptors both in the round and in relief. The headless male figure in the round and the Brahmani bull in relief on the seal of Mohenjo-Daro are instances in point. Besides these, the artists of this period were also proficient in making images in metal. A fine example of a bronze figure is the dancing woman whose head-dress and the way of covering her left arm with bangles are features of great interest. This figure cast by the process called the "lost-wax" process is interesting because the bronze figures of much later periods were also made by the same process, suggesting thereby the great popularity of the process through the ages with the Indian artists.

The Vedic period which followed in the wake of the Indus civilization is represented by very few antiquities. Whether stone sculpture was practised during this period is not definitely known. However, from the copious references found in the literature to images, it would appear as though figure sculpture in perishable materials such as wood was in vogue but owing to the impermanent character of the material they did not survive. Although large figures belonging to this period have not come down, figurines in clay representing the last phases of the period have been met within several places in North India. These figures in general are hand-made and show primitive features. Nevertheless a good number of them are done so beautifully as to prove unambiguously the fact that the art of sculpture continued to be practised with undiminished vigour and with high plastic qualities. In fact, it may be said that these figurines were the proto-types of the beautiful figures produced later on in different parts of India where the traditions of the art as seen in the clay figurines were not only kept alive but also greatly improved upon.

Mauryan sculpture.—The subsequent historic period witnessed the rise of the two great religions, Buddhism and Jainism. The followers of these religions were probably the first to develop the art of sculpture, particularly sculpture in stone. But an unprecedented briskness in this field of creative activity became evident only from the third century B.C. Asoka, the great Mauryan emperor, was not only a devout Buddhist, but also a great patron of art which he employed so successfully for spreading Buddhism far and wide. The chief works of art of his period are the stupas, the pillars and a few rock-cut caves in Bihar. Of the sculptures of this period two groups are met with, one group done in the traditional Indian way; and the other group done in the Persian way. The most important examples of the former group are the figures of Yakshas from Parkham (now in the Mathura Museum) and Patna; a Yakshi from Besnagar (now in the Indian Museum);

the front parts of an elephant at Dhauli in Orissa; the Chauri-bearer (Pl. I) from Didarganj (now in Patna Museum); the frieze of elephants in the Lomas Rishi cave in Bihar and the Rampurva bull which formed the capital of a pillar. These figures show features characterised by vigour, volume and mass. In addition to these, the very decoration of these figures is unmistakably Indian. Above all the subtle and most effective way of expressing inner strength and feelings of emotion is truly native to the soil and shows the consummate mastery of the sculptors in the traditional lore of this art.

The main elamples of sculptures in the Persian style are figures of animals which topped the pillars erected by Asoka. These are distinguished by realistic delineation of features and the high polish of the surface. Moreover amongst the decorative details of these are found motifs which are foreign. These facts go to prove that there was active intercourse between India and Persia: and Asoka in his zeal to propagate Buddhism did not hesitate to get help from foreign artists. The best example of this style is the Saranath lion capital which has been adopted as our national emblem.

Sunga sculpture (180 B.C. to 100 B.C.).—During the reign of the Sungas the art of sculpture was developed still further and surprisingly the examples of sculpture of this period are in the pure indigenous style, not free yet from archaic features, which suggests that the art had not yet advanced much. The sculptures of this period are exemplified mainly by those of the Bharhut stupa (Indian Museum) and those of the stupa No. 2 at Sanchi; and they show signs of emerging from the primitive style into a classic one.

Early Andhra sculpture.—Next to the Mauryas, the credit for producing sculptures of great artistic merit on a large scale goes to the Andhras. The early members of this dynasty were contemporary with the Sungas. The Andhras were responsible for the construction of the great gateways of the Sanchi stupa in Bhopal State. Here the sculptures are in a much advanced style and show "fine composition, perspective and detail". A few sculptures produced in the same period in the Krishna valley are available but they show primitive features. Representing this early period there are only a few Jain sculptures and a few Hindu sculptures. The Jain sculptures of this period excavated at Kankalitila near Mathura are exhibited in the Museum at Mathura and they include beautiful Yakshi figures. The Hindu sculptures of this age are exemplified by the famous *linga* at Gudimallam (Pl. II) in the Chittoor district and the *linga* and a terracotta medallion from Bhita near Allahabad.

Later Andhra sculpture.—The most noteworthy examples of sculpture of this period are those that adorned the Buddhist stupas erected in the Krishna valley between 100 A.O. and 300 A.D. A significant and important collection of sculptures was discovered

at Amaravti, the ancient capital of the Andhras, where stood one of the most wonderful stupas, adorned all over with exquisite sculptures. They belong to different periods and consequently show differences in their workmanship. The sculptures of the period ending about 100 A.D., are poor of workmanship compared to the ones that were carved on the railing round the stupa eracted about 150 A.D. (Pl. III). These later sculptures reveal classic qualities, such as beautiful modeling, restrain in decoration, perspective and vigour, although there was overcoming in the compositions. Examples of sculptures from Amaravati, Goli, etc., dating from about the beginning of the 3rd century, A.D. show slight conventionalism and stiffness.

Indigenous sculpture of Kushan times (100 A.D. to 300 A.D.).—To this period belong some of the Jain sculptures from Mathura mentioned above and a Yakshi now in the Bharat Kala Bhavan, Banaras. The early works of this period, as should be expected show archaic features and are rigid. But the sculptures of the 2nd century A.D. are more graceful and voluptuous in feeling than even the Andhra sculptures, the Yakshis of the Bhutesar railing from Mathura being particularly beautiful. It was during the latter part of the first century A.D. that the image of the Buddha was created for the first time by the indigenous sculptors. The Kushan Buddha figures in the indigenous style are true to the Indian fashion, and are good examples of the art which tended to idealise spiritual perfection rather than the physical beauty as was the character of Greek art. In the sculptures in the indigenous style the Buddha was shown only by symbols up to about the 1st century A.D., while in the Gandharan sculptures which are influenced by Greek and Roman art human figures of the Buddha appear from the very beginning. But in South India the Buddha was shown as a human being as well as by symbols, a practice which continued till the 3rd centry A.D. when the Andhra rule ended.

Graeco-Buddhist sculpture.—The art of sculpture was well established even in the 2nd century B.C. in the North-western part of India. Here the families of Greek sculptors who accompanied Alexander had been living for a considerable period, continuing the Greek art traditions. When the Kushanas came to power they encouraged the development of these art traditions with the result that a vast quantity of sculptures relating to Buddhism have been discovered in this area. A great majority of them belong to the time of Kanishka a great patron of art, who was ruling from Peshawar. The art received a setback about the 3rd century A.D. here, but it was again revived about the 5th century A.D. and examples of sculptures of this phase, mostly done in stucco, are excellent.

The Gandharan sculptures of the early period are also formal, while those of the " Indo-Afghan " period exhibit qualities, such as vitality, freedom and realism. The sculptures of the earlier period

are executed in stone while the later ones are in stucco. The main difference between the Gandharan and indigenous styles is that in the former greater attention is paid to the details of human body than to spiritual qualities which are a distinctive feature of the sculptures of the indigenous style of all periods.

Gupta sculpture.—The sculptures of this period (4th to 6th century A.D.) are numerous and they consist of specimens illustrating themes of all the three religions. The style of sculptures shows a continuation of the indigenous Kushan style but rapidly tending towards idealism. "In its classical restraint and mastery of materials, the sculptures of this period resemble the works of the Greeks several hundred years earlier." The Buddha figures (Pl. IV) of the Gupta period have as a rule, their aureole covered with beautiful carvings of foliage and other miniature figures, and worshippers are shown at the feet of the Master. Some of the most beautiful specimens of this period were discovered at Sarnath.

Chalukyan sculpture and its derivatives.—In the Deccan the art of sculpture was developing in a mixed way. It retained all that was best in the indigenous style such as the decorative features, the supple limbs and the details of human body characteristic of the region, while it was much influenced by the Gupta art traditions which were carried over to Western India through the intervening territory ruled over by the Vakatakas. Beautiful examples of sculpture of the early Chalukyan period (6th to 8th century A.D.) are available at Badami, Pattadakal and Aihole. The sculptures of the Eastern Chalukyas who were ruling on the eastern coast with Vengi as their capital differed a little from those of Badami. But the Vengi school was influenced by the art of Amaravati to a great extent. The Rashtrakutas who came to power in Western India after defeating the Badami Chalukyas, continued to patronise the art and were responsible for the wonderful temple of Kailasa at Ellora (8th century) as well as for the beautiful Jain sculptures discovered at Danavulapadu (now in the Government Museum, Madras).

The Western Gangas of Talakad also contributed to the development of the art of sculpture and it was during their regime the colossal monolithic figure of Gommatesvara, 57 feet high, was carved on the hill at Sravana Belgola in the Mysore State.

Beautiful sculptures belonging to about the 10th and 11th centuries A.D. have been discovered at Hemavati in the Anantapur district. These were made during the rule of the Nolambas who were feudatories of the Western Gangas and others. The sculpture is in the Western Chalukyan style although a few elements of the art of sculpture of the Tamil country are found in these works. The details of carving such as Siva's hair, etc., betray Tamilian influence. Contemporary with the Nolambas were the later Western Chalukyas. Representing their period are a number

of sculptures which show features akin to those found on the sculptures of the early Chola period but with this difference that their decorative details are influenced by the Deccani school.

The Hoysala school of sculpture which flourished between 1100 and 1300 A.D. is reputed for vigorous modelling, plumpy physique and an extraordinary richness of decoration. The delicate carving of these sculptures is in fact in the nature of carving in more pliable materials such as wood, ivory, etc. Examples of the Hoysala sculptures are to be found in the Mysore State, in the temples at Belur, Halebid and Somnathpur.

While the Hoysala school of sculpture was producing such wonderful sculptures in the western Deccan, the school patronised by the Kakatiyas of Warangal who were contemporary with Hoysalas, was producing sculptures which showed a combination of the Western Chalukyan and the Eastern Chalukyan traditions. The figure sculptures are elongated and they are shown in interesting poses embellished with ornaments and costumes equally interesting and characteristic of the locality.

Tamilian sculpture.—The sculptures of the Tamil country dating from the 7th century are simpler in treatment than those from the Deccan. " In the lines of its figures, in its treatment of eyes and the absence of canopies, this sculputure resembles the Amaravati sculpture, but it has more rugged strength than the Amaravati and Gupta sculpture." The poses of the figures are treated less heavily in this sculpture than in the Chalukyan specimens. As in the case of architecture, the Chalukyan and Tamil sculptures were developing independently till Vijayanagar period when the traditions of the Tamilian sculpture began to dominate.

The five periods of Tamilian architecture—Pallava, Early Chola, Later Chola, Vijayanagar and Modern—have each its own characteristic type of sculpture too. A gradual evolution of the features of the sculpture is met with as time passed on.

Pallava period.—The figures are natural in pose and their modelling is fine. The draperies are heavy and the ornaments are few and delicately carved. Feminine figures are extremely graceful and their workmanship immediately brings to the mind the voluptuous women of the Amaravati sculptures. In general the sculptures of this period are distinguished by an extreme simplicity of treatment and gracefulness of form and high restraint of decorative designs.

Early Chola period.—The sculptures of this period are noted for their classical restraint and grace, reminiscent in feeling of the earlier classical Gupta sculptures of the North. In pose and moulding they tend to be formal although in the best examples (Pl. V) a high degree of grace and dignity are easily seen.

Later Chola period.—The sculptures of this period show a marked tendency to conventionalise the poses, draperies and ornaments. Nevertheless there have come down to us a few sculptures of this period which have preserved the lingering classic traditions of the earlier period.

Vijayanagar period.—The examples of sculpture of this period show an elobration of details such as draperies and ornaments, which is unknown in the sculpture of the earlier periods. The poses and forms themselves are still more conventionalised. The face is somewhat expressionless with sharply pointed and prominent noses and vertically grooved chin. Examples of these are to be found at Hampi in the Bellary district and in the temples and towers erected by the Vijayanagar kings in the different parts of South India.

Modern period.—Even during the post-Vijayanagar period the art of sculpture especially the religious sculpture, was practised widely as will be testified to by the examples of sculpture that are seen in the temples built during this period. They are usually stiff and lifeless with unduly prominent noses and conventionalised draperies and emblems. The general character of these sculptures is rigidity.

Metal sculpture.—Side by side with the stone carving, there existed the practice of making artistic images in metal. That the art of bronze figures was in vogue in the 3rd millennum B.C. is exemplified by the small bronze figure excavated at Mohenjo-Daro. Coming down to the historic periods, the metal figures that belong to the period from the 1st century A.D. to about the 5th century A.D. are also few. Kanishka's relic-casket with figures of seated Buddha and others, from Peshwar, is a well-known example of the art of the 2nd century A.D. But the figures are not fine and do not compare well with the contemporary stone figures. Perhaps the immature technique of working in bronzes might be a reason for their somewhat primitive features.

A good number of examples of Buddhist bronzes of the Gupta period have come down chiefly from Kurkihar. But there is nothing to excel the superb bronze standing Buddha figures from Sultanganj now in the Birmingham Museum. To an earlier period than this belong the bronze Buddha figures unearthed at Amaravati now in the Madras Museum. But unlike the Sultanganj Buddha, these Amaravati ones which are the earliest examples of bronzes of South India, show features of undeveloped style although the faces are highly expressive of qualities of self-possession and spiritual calmness. In north India, bronze figures were produced, in some quantity, during the Pala and Sena periods in the Bengal region while in the other regions not much attention was paid to this art. In South India, bronze casting was in vogue. on a restricted scale during the Pallava period, greater attention having been paid to the art of stone sculptures. Further, bronze

figures were not necessary in that period because there was no rigidity regarding the admission of people into the temples which therefore naturally restrained the use of such movable figures intended for purposes of taking out in procession, a practice which became universal during later periods. The few images in metal, claimed to belong to this period, show the same characteristics as are met with in the stone sculptures of the period. This is true also of the metal figures of the subsequent period. Of course, there may be some little difference in the modelling and decoration, etc., between specimens of metal figures and those of stone which is inevitable because of the difference in the materials and the technique employed. The sects of Vaishnavism and Saivism having become well established by about the 11th century, and caste distinctions also having come to stay, the practice of restricting admission only to high caste people into the temples came to be practised widely. This necessitated the taking out in procession the images of gods and goddesses so as to enable the masses of people who were denied entry into the temples to have *darshan* of the Lord. So there was need to make a larger number of these portable metal figures as it was not easy to move out the stone figures permanently installed in the sanctum. Consequently a very large number of metal figures dating from 11th century A.D. have come down to us. Amongst them are found images of gods and goddesses of the Hindu pantheon as well as Buddhist and Jain images.

Of South Indian metal figures, those of the Chola period (950 A.D.—1300 A.D.) are charming and dignified. Especially the groups of Vishnu with Sridevi and Bhudevi and Rama (Pl. VI) with Sita, Lakshmanan and Hanuman, in the Madras Museum and National Art Gallery, Madras, respectively, are excellent specimens of the art. Above all, the metal figures of Natesa produced during this period, have evoked admiration of artists and connoisseurs from all over the world. Of the Natesa figures, one from Tiruvalangadu in the Chittoor district and another from Velanganni in the Tanjore district are masterpieces of metal work and the French artist A. Rodin went into raptures over them. Another interesting Natesa from Punganur is illustrated here (Pl. VII).

Terracottas.—As forming an important item in folk rituals and cults, hand-made terracotta or clay figures have been occupying a special position for a long time in Indian art. A large number of examples of this folk art have been unearthed in Mohenjo-Daro and Harappa among which the figures of the Mother Goddess type abound. But, as a rule, the human figurines are somewhat crude compared to the animal and bird figurines.

As in the case of the other arts, few specimens of this art belonging to the period from 2000 B.C. to 300 B.C. have been discovered. But a quantity of such figurines, made by hand and with archaic features such as are found on the figurines

of Harappa culture have been discovered in different parts of North India and they have been assigned to a period earlier than the Mauryan period. The examples definitely attributed to the Mauryan period are seen to continue the older traditions, and among these grey coloured figurines are noteworthy. A little later in the Sunga period, the figurines while being still in the round are worked by a double process, namely, the hand-made body affixed to the head, made from a mould. This technique came into use for the first time now. After the introduction of the use of complete moulds, about the first century B.C., the art made rapid progress, and moreover the examples done in this style tended to be more artistic in quality than those of the previous period. The well-known examples of this period are the ones discovered at Mathura, Kosambi, Ahichchatra, Patna, etc. More far-reaching than the technique was the replacement of religious figures by secular ones with the result that a large number of figures of men and women and of couples (*mithunas*) in different poses, etc., were produced during the period. A number of terracottas of this and the subsequent periods were also found at Pondicherry in South India.

During the Kushan period, the art reverted to the hand-made technique. As a result of this, the examples are crude. But this state of affairs did not continue for long, as, with the advent of the Gupta age, the terracotta figures came to occupy a position similar to sculptures in stone and big temples built of brick began to be decorated with beautifully carved terracotta plaques. The surviving brick temples at Bhitragoan (Kanpur District) and Sirpur further show that moulded bricks were also used for buildings. Of the Gupta terracottas, a good number are plaques pressed out of moulds; but an equal quantity of large panels in high relief for use in buildings was also met with. This art persisted up to recent times as would be seen by the brick temples of Bengal and the figures of folk deities of South India.

Paintings—Murals.—The graphic art has had a long history in India. A variety of folk-*cum*-symbolic painting was in vogue in the 3rd millennium B.C. The examples of this art are both in single colour (monochrome) and in several colours (polychrome). The traditions of paintings were continued in the subsequent periods. They were also much improved upon. The fact that the painter's art was much encouraged is proved beyond doubt by the numerous references to the halls of paintings (*chitrasala*) and teachers of painting in the literary works of different periods and localities. There is a separate section in the *Vishnudharmottaram* devoted to the technical aspects of painting.

The earliest extant examples of painting date from the 2nd—1st century B.C. and are found in the caves Nos. 9 and 10 at Ajanta. They are vigorous in their lines and imbued with a naturalism not yet completely freed from archaic features.

There is an abrupt break and further examples of the art are available only from the 5th century A.D. They are again at Ajanta in the later caves, such as cave No. 16 and the caves at Bagh. The subjects are Buddhistic, and along with the delineation of the Buddha and the Bodhisattvas, a number of domestic scenes revealing a vast panorama of social life of the times are painted. It has been remarked by very competent critics that although the paintings abound in details, there is rarely a repetition of any one of them. This fact shows unmistakably the deep knowledge of the artists. Above all, the expressions of the figures in them are superb. Famous examples of the paintings of this period are the Bodhisattva Padmapani in cave No. 1 the Mother and Child in cave No 17, both at Ajanta and the scene of merriment and dance in the Bagh cave.

In this connection, it has to be said that a large number of Buddhist caves containing wall paintings were discovered in places such as Bamiyan in Afghanistan and other places in Central Asia. These paintings are dated from the 5th century to the 9th century A.D. Although these examples show a mixture of Indian, Iranian and Chinese traditions, the earlier specimens are predominently Indian. It is through this route that the traditions of Indian Art, particularly of painting, travelled to China and Japan.

In South India, the art of painting has been a fashion from very early times. But owing to the non-survival of any kind of structures belonging to periods earlier than 600 A.D., neither specimens of sculpture nor those of paintings of this period have come down to us. At the beginning of the 7th century A.D., the artists of South India were very active and examples of wall paintings of this period are found in the famous Jaina cave temple at Sittannavasal near Pudukkottai, attributed to the time of Mahendravarman I of the Pallava dynasty. Although the murals of Sittannavasal are a little later in date than the Ajanta paintings, a close scrutiny will show the remarkable height to which the art was developed in South India at that time and the vast difference in the form, content, details, expression, and the technique between them and the Ajanta paintings. Later examples in the same style are found in the Kailasanatha temple at Kanchipuram and in the Siva temple at Panamalai, both of about 700 A.D.

That the traditions of the painting were continued in the subsequent periods is shown by the paintings on the walls of Jaina caves at Tirumalai in the North Arcot District, dating from the 10th century A.D., and the 11th century wall paintings recently brought to light in the Big Temple at Tanjore, a noble edifice built by the Great Raja Raja Chola I. The superb rythmic movement, great vigour, and beauty seen in the figure of the dancing girl at Sittannavasal are continued in the dancing girl in the Brihadisvara temple at Tanjore.

Later examples of the art of painting in South India are found at Hampi, Somapalle, Lepakshi and in a number of places in the Kerala State such as Trivandrum, Padmanabhapuram and Mattancheri.

Miniature paintings of Eastern India.—While the development of wall-painting was going on as noticed above, there was a reaction against it which manifested itself in the growth of miniature paitings, in Eastern and Western India. Generally the miniatures took the form of illustrations of manuscripts, and the subjects dealt with are gods and goddesses of Buddhism and Jainism. This art is characterised by simplicity in composition and flowing lines as well as glowing colour schemes. It is exemplified by the representations in the famous Buddhist work Prajnaparamita dating from the 10th—11th century A.D. of the Pala period.

Western India.—In Western India, miniature painting has had a continuous history from 1100 to 1600 A.D. The paintings were illustrations of Jaina manuscripts, the earlier ones having been done on palm-leaves and later ones on paper. The early specimens show the use of red colour in the background while the later ones show the use of blue and gold. The noteworthy characteristics of these western Indian miniatures are angular faces with protruding eyes, pointed noses and great elaboration of decorative details. The subjects are from the Jaina texts such as the Kalpasutra, and the Vaishnava texts such as the Gitagovinda, Bhagavata, etc. The secular paintings mainly deal with the theme of love.

Rajasthani.—The miniature paintings produced at the courts of the Rajput kings form a distinct group and they were contemporary with the miniatures produced in the Mughal Court at Delhi. Beginning with the 16th century A.D., the Rajasthani school has had a varied development and its influences are met with in the independent hill schools of the West Himalayas of 17th and 18th centuries A.D. The chief quality of the Rajasthani paintings is their idealistic representation of the emotional aspects of the Indians. The figures of human beings and those of animals and birds are also idealistic. The themes are varied and the sentiments of love and devotion are mingled with an exuberant joy of life, the common subject-matter being the Krishna legends. The most important class of Rajasthani miniatures is the series of Ragamalas or paintings of the musical modes. These modes afforded great opportunities for artistic treatment. The best examples are those of the 17th century A.D.

Pahari or Hill Schools.—The examples of miniature paintings found in sub-Himalayan States such as Jammu, Basholi, Chamba, Kangra, etc., are also in the same tradition. Of these the Kangra and Tehri-Garhwal schools produced a number of good specimens during the 18th and the early 19th centuries. The subject-matter was Krishna's boyhood pranks and his love episodes with Radha.

The Basholi paintings being characterised by the use of brilliant colours and vigorous lines rank high amongst the works of the Himalayan schools.

Mughal.—The Mughal emperors were enlightened patrons of art, and they encouraged the art of painting. Akbar and some of his successors are said to have learnt the art themselves and invited master artists to their courts for executing illustrations for many a masterpiece of Sanskrit and Persian literature. Among these illustrated works are the Ramayana, the Akbar-nama, the Mahabharata and a host of other works. Besides these book illustrations, a number of portraitures of emperors and noblemen and court scenes were also painted. The Mughal school was eclectic and its works show a judicious combination of elements from other schools. A clear distinction of paintings of the Gughal school is found in the various facial types of different persons actually painted from life while in the Gujarati and Rajasthani paintings the idealised facial type is repeated.

The paintings done during the regime of Jehangir are mainly episodes from his life and they are distinguished by delicacy of line and beauty of colouring. Many beautiful paintings of animals by Ustad Mansur of Jehangir's court have survived.

The art of miniature paintings enjoyed as high a position in Shajahan's time as in the previous periods. But the paintings of his period reveal careful treatment and fine decorative details although they are somewhat conventionalized. Owing to lack of encouragement painting naturally began to decline during Aurangazeb's rule. Artists from Delhi went in search of new patrons. Thus a good number of artists came down to the Deccan, where they found patronage not only from the rulers of the various Muslim kingdoms but also from those of the Vijayanagar empire. A good number of miniatures of the Deccani school have been preserved. While they are not of good quality so far as draftsmanship and expression are concerned, they are distinguished by some characteristic embellishments such as carpets, balustrades and furniture not met with in the Mughal or Rajasthani miniatures. Further there have been set-backs in the history of this art in the Deccan owing to the frequent political changes. The result was decadence. Nevertheless a few specimens such as the Yamapata paintings from Cuddappah show a high level of artistic achievement not only in composition and colour scheme but also in the vigorous and precise lines.

Bazaar paintings of Tanjore and other places.—The art of miniature painting was also patronised by the Maratha kings of Tanjore and by people in general in such places, as Patna, Delhi, Calcutta, Banaras and Lucknow. They are mainly portraits, and preserve the traditions of decorative details. The class of miniatures portraying men and women of different communities and animals and birds, are specially noteworthy for their almost photographic

exactness and clarity details. This realistic approach was due to the influences of European art. Although the earlier Tanjore miniatures are tolerably good the later ones show progressive deterioration in quality, finally to be superseded by a type of Western art not worthy of mention.

Arrangement of the materials of History in a Museum. —The above introduction to the various aspects of the archaeology of the historical periods of India, is intended to give a museologist the theoretical basis for his more important work, namely, the imparting of the knowledge of the ancient history of India to the visitors and students by means of effective display of the materials of history in his museum. The importance of this method is that instead of teaching vocally, the visitors are taught through visual aids. These materials include all things that the human mind could conceive and the human hand could produce. Broadly, they may be classified under various heads such as pots and pans, food materials, costumes and jewellery, toys and dolls, vehicles and conveyances, tools and weapons, residential buildings and religious edifices, coins, weights and measures, art and literature and a host of other things. According to the availability of the space in, and the resources of, a Museum, the display of these articles may be either elaborate or limited. In either case it is necessary to divide the materials into well recognised groups period-wise in a chronological order. This may be done as follows :—

THE MOST ANCIENT INDIAN CIVILIZATION OF THE INDUS VALLEY.

(3000 B.C to 1500 B C.)

- Men, women and children.
- Food materials.
- Costumes and jewellery.
- Buildings, religious and secular.
- Art and literature.
- Toys, etc.
- Cult objects.
- Seals and sealings.

Now the question arises as to where exhibits to illustrate this period of Indian history can be got from, as the number of items of antiquities bearing on this civilization is limited. They are preserved in the National Museum, New Delhi, and in the Department of Archaeology of India, New Delhi. It will therefore be difficult to get original specimens of these. In such cases actual casts from, or authentic replicas of, the originals may be obtained from those two institutions. Even supposing that it is difficult to get such casts, etc., a person planning to build a museum need not get disheartened. He may get photographic enlargements of

at least a few articles representing each of the various groups of antiquities and display them in his museum. Each exhibit whether original, cast or replica or photographic print should be properly mounted and provided with a brief but tellingly-worded label in three languages, namely, regional, national and international languages.

Another essential thing to be borne in mind is to show at the commencement of this display-room a large map of India with the Indus Valley region marked out prominently in bold colours. Important sites such as Mohenjo-Daro and Harappa where the bulk of the antiquities were unearthed should also be indicated by bold letters. This map must be followed by a general label which gives in a nut-shell all the salient features of this civilisation. These two items will be found useful by the educated adults visiting the museum. In order to make children and the illiterate adults understand the chief characteristics of this civilization there should be a large picturesque chart at the end of the display-room. This chart should have at the left hand side simple titles in three languages, of important aspects of the civilization written in bold letters. Against each title should be shown diagrams and sketches that can be easily understood by the children and the illiterates. The chart for display-room in question may be as follows :—

INDUS CIVILIZATION.

(3000 B.C.—1500 B.C.)

TOOLS OF COPPER AND STONE ONLY.
IRON TOOLS NOT COME INTO USE.

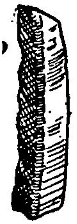


Fig. 99. Stone Scraper.

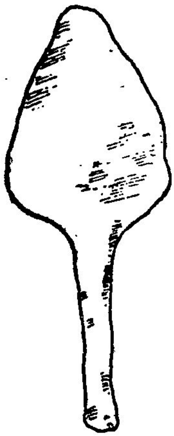


Fig. 100. Copper Arrow-head.

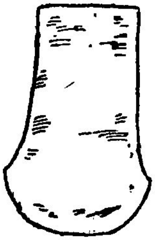


Fig. 101. Copper Axe.

HOUSES BUILT OF LARGE BURNT BRICKS.
STRAIGHT STREETS CUT AT RIGHT ANGLES.
DRAINAGE SYSTEM PERFECT.
IN SHORT, WORLD'S FIRST PLANNED CITY.

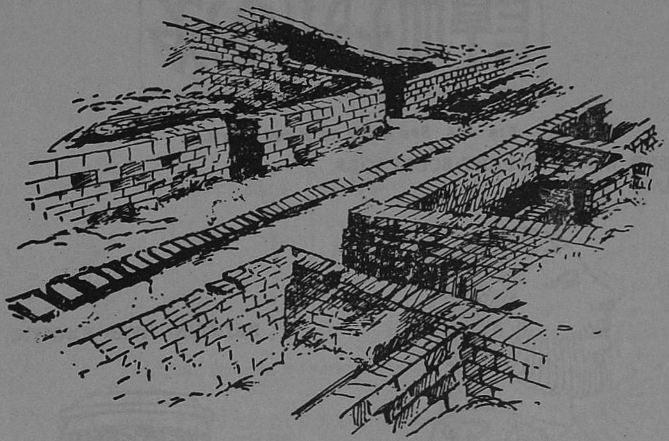


FIG. 102. STREETS AND HOUSES.

WHEAT WAS STAPLE FOOD OF THE PEOPLE.

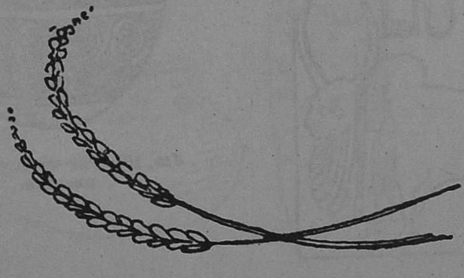


FIG. 103. WHEAT SHEAF.

PEOPLE WROTE AND READ PICTURES.

THEY DID NOT KNOW ANY ALPHABET.

Fig 104. Specimen of Pictograph.

THERE WERE EXPERT SCULPTORS.

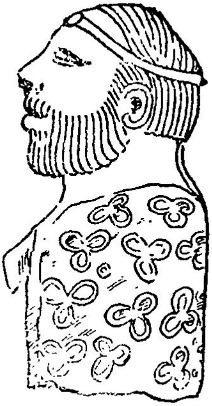


Fig. 105. Sculpture in the round of a chief ?

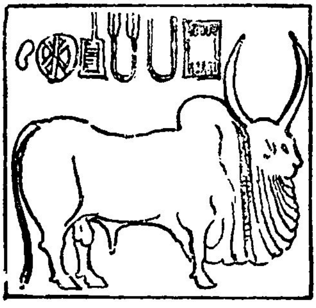


Fig. 106. Sculpture in bas-relief.

PAINTING WAS KNOWN.

Fig. 107. Pot with painted designs.

DANCING WAS KNOWN.

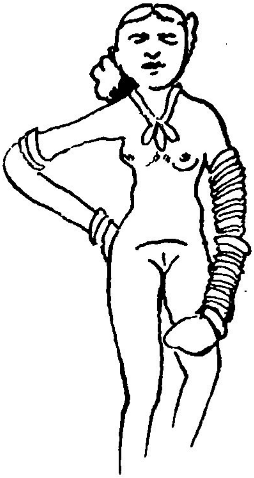


FIG. 108. BRONZE DANCING WOMAN.

CLAY TOYS AND IMAGES, A SPECIALITY

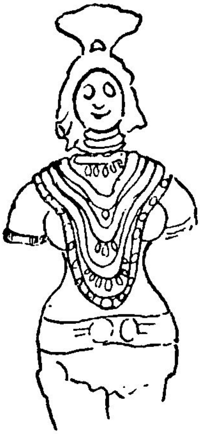
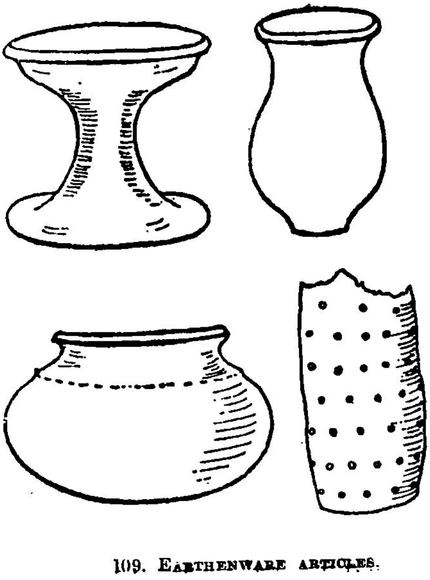


FIG. 110. TERRACOTTA FIGURINE OF MOTHER-GODDESS.

MUD POTS OF VARIOUS DESIGNS WERE MADE.



109. EARTHENWARE ARTICLES.

SAIVITE RELIGION WAS IN VOGUE.

FIG. 111. SIVA-PASUPATI.

DEAD BODIES BURIED IN COFFINS.

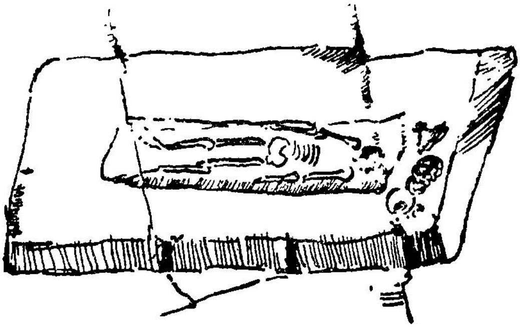


FIG. 112. BURIAL IN COFFIN.

The display-room should be spacious and the exhibits kept to the minimum. All the small items of exhibits, photographs and charts should be shown at the eye level of a boy of 12 to 13 years of age. If there was wall space above the exhibits, which gives an impression of emptiness and monotony, it may be filled up with suitable panels of paintings. Each of them may depict a scene of life of those times. These paintings will of course be imaginary. But nevertheless if the representations of men, animals, designs, costumes, etc., are similar to those associated with the civilization the painted panels will add to the effect of the display and their colourful character will be appealing, especially to the young visitors. Thus they well assist the retention of the facts in the memory of the visitors.

The next period of Indian history is between 1500 B.C. and 600 B.C. It is represented by the Vedic literature and is therefore called the Vedic period. No significant antiquities belonging to this period have been unearthed. But the evidence furnished by the literature about the social life of the period is such that it is possible to reconstruct it, somewhat satisfactorily, under the various headings as mentioned under the previous period. There are also quite a number of new headings characterising this period :

VEDIC PERIOD.

(From 1500 B.C. to 600 B.C.)

Men.	Food.	Costume Jewellery, etc.	Houses of Gods and men and ritual altars.	Sacrifice.	Literature and Philosophy.	Religious systems.	Art.	Scientific pursuits.	Domestic life.

In view of the fact that antiquities representing this period are few, the section devoted to this period may have to be filled with charts and murals. In this section also, a large map of India showing clearly the extent of the area which was influenced by the Vedic culture may be exhibited. The chart at the end of the

section can contain only topical headings, as the headings cannot be illustrate with diagrams, etc., of actual specimens. This chart may be as follows :—

VEDIC PERIOD.

1500 B.C —600 B.C.

1. Compilation of the Vedas called Rig Veda, Yajur Veda, Samaveda and Atharvana Veda.
2. Iron came to be used widely.
3. Kingdoms and Republics were established.
4. Great thinkers like Janaka, Yajnavalkya, and the other sages lived.
5. Various cu'ts and religions were practised.
6. Palaces and houses built of wood and brick existed.
7. Varnasrama system was introduced.
8. Elaborate arrangements for war were developed.

Even here the wall space may be filled up with panels of paintings depicting scenes from the Vedas and Upanishads.

Similarly separate sections may be arranged for the following periods :—

North India—

1. Nandas and other dynasties.
2. Mauryas.
3. Sungas.
4. Kushanas.
5. Guptas.
6. Vardhanas.
7. Palas.
8. Gurjaras.
9. Rajputs.
10. Muslims.
11. Mughals.

Deccan—

1. Andhras and Kalingas.
2. Kshatrapas.
3. Kadambas and Vakatakas.
4. Badami Chalukyas.
5. Eastern Chalukyas.
6. Rashtrakutas and Gangas.
7. Chalukyas of Kalyani.
8. Kakatiyas and Hoysalas.
9. Vijayanagar.

South India—

1. Third Sangam Age.
2. The Cheras, the Cholas and the Pandyas
3. Pallavas.
4. Pandyas.
5. Imperial Cholas.
6. Later Pandyas.
7. Vijayanagara Viceroys or Nayaks.

Replicas of originals belonging to these periods may be made to order with the help of the department of Archaeology, Government of India, New Delhi and the Departments of Archæology of the various States where the relics of the above mentioned periods exist. In the absence of replicas, photographic prints may be obtained from the same authorities and displayed.

In every section, the map, general label, labels for individual exhibits and the summary chart are essential concomitants. Mural paintings are optional.

Collection.—Besides obtaining the necessary exhibits from the institutions specialising in archaeology, the men planning a museum can collect minor antiquities such as coins, miniature paintings, inscriptions on portable materials, costumes, etc. These also may be purchased from private dealers. Securing of such antiquities bearing on the history and culture of the locality where the museum is located will be easier. In fact a museum should start with materials of local interest and gradually develop into museums of State importance or of National importance.

Coins can be found in ancient city or town sites. They will be usually covered by earth and will be visible after a heavy downpour of rains. Miniature paintings, ivory works, etc., may be purchased from persons associated with ancient royal households.

Replicas and casts.—These can be made of any material. Usually plaster of Paris is employed for the purpose. An artist or modeller is necessary for making replicas of larger or smaller sizes than the originals. A trained person will do for making actual casts of specimens. There are various methods of taking plaster-casts from the originals, especially of sculptures and carvings. But the most common method is the piece-mould method. Piece-moulds made of plaster of Paris will last for a long time; piece-moulds of clay will be useful for taking casts only once. Making of plaster-casts of coins is comparatively easier.

After making the casts, they will have to be trimmed and coloured according to the colour of the originals before they are displayed in the gallery.

Packing and transport of sculptures.—Stone sculptures, bronzes, carvings, etc., require careful packing before they are transported from the place of acquisition to the Museum. The following is one of the safest methods :—

Each piece of sculpture. etc., should be covered first with tow or packing cotton and tied to the specimen. This is covered then with oil cloth. Then hay, stiffly twisted into the form of rope should be wound closely round the sculpture from its head to base. This kind of covering enables the sculpture to absorb all shocks. This bundle should be packed in a box made of strong wooden

planks. The bundle should be placed on six inches deep hay or tow or some such suitable packing material. Further all around the bundle there should be space about six inches wide which should be tightly packed with any one of the packing materials. Instead of filling the space with loose hay, etc., hay may be stuffed into small pillows and placed all round the bundled sculpture as padding. This method is a slightly better one. Then the box is closed with its lid using strong screws at close intervals. The box is afterwards bound by iron tapes. The box should be provided with coir rope handles which make their shifting, handling, etc., easy. Then the addresses of the receiver and the sender are painted on the lid legibly and neatly. If the material is fragile, it should be boldly written in a few places on the box. It is always advisable to send the package as insured railway parcel. It is also advantageous to entrust the transport and booking of the package to reputed transport agencies.

Paintings, etc.—The packing of paintings, textiles, plaster casts of coins, manuscripts and so on should be done differently. As far as possible frames and glass-panes of paintings should be removed before packing. Then each of them is put between two sheets of rough paper. Then the whole lot of paintings is put between two stiff card-boards which are wound round by twine or country twine. This bundle is afterwards placed in an oblong or square or circular tin or wooden box made to the required size with at least two inches of free space all round the bundle. The space is filled with packing cotton. Besides, at each of the four corners of the box, both below and above the bundle, there should be placed, across, a bit of wood. It is intended to absorb the shock during transport of the box and prevent the paintings, etc., from being damaged even to a slightest extent. Then the lid is fixed to the box; and the box covered with oil cloth and properly stitched and sealed. The addresses of the receiver and the sender should be written legibly on it; similarly the word FRAGILE also should be prominently indicated. The packages of this kind should invariably be insured and sent by post, instead of by railway parcel. Railway parcel transport may, however, be adopted in case a very large number of items are to be sent or paintings, etc., with frames and gless-panes are to be sent. In this case the articles should be packed not in boxes of wood of the types mentioned above but in strong steel boxes, which will not bend even slightly except during extraordinarily careless dropping or handling. The framed paintings, when placed inside such boxes, should be provided with sufficient quantity of padding between two paintings so as to prevent their glass-panes from being damaged due to careless handling. Just as in the case of packing, great care should also be exercised while unpacking the packages. Before proceeding to unpack, it is essential to note down the condition of the packages. After unpacking one by one the articles should be carefully examined and stored.

Registerng the articles.—After acquisition, the antiquities should be entered in a General Accession Register with brief descriptions and measurements of them. This register may have the following columns :—

GENERAL ACCESSION REGISTER.

Serial number.	Date of accession.	Brief description of the article.	Material.	Measurement.	Provenance.
(1)	(2)	(3)	(4)	(5)	(6)

Cost.	Reference to records.	Initials of the custodian.	Initials of the supervising authority.	Remarks; reference to classified accession register.
(7)	(8)	(9)	(10)	(11)
RS. nP.				

In this register the articles may be entered year-wise, conveniently calendar year-wise, i.e., the first of the series commencing in January and the last of the series ending with December of a year.

The advantage of having this register is that at a glance it will be possible for one to say the number of items added to the collections year by year.

After study of the individual items, which in several cases can be done only after the articles are cleaned and restored, the antiquities should be classified and entered in a special register for each group of articles, e.g.

REGISTER FOR SCULPTURES.

Accession number.	Date.	Detailed particulars.	Material and size.	Provenance.	School or type and date.
(1)	(2)	(3)	(4)	(5)	(6)

Whether treated, if so when.	Reference to publication.	Cross reference to general accessions register and initials of the supervising authority.	Remarks.	Where kept.
(7)	(8)	(9)	(10)	(11)

The accession number in this variety of register may be continuous. When individual items are entered separately, the total number of items of a particular group may be easily known at any time. Besides, this register will serve as the basis for the preparation of a detailed printed catalogue or monograph.

The custody of these registers may be as follows: The general accession registers may be kept by the supervising officer wherever there is such a separate officer. The classified registers should be kept by the custodian or the keeper of the section. Some inconvenience is likely to be caused in filling up the cross-reference columns in both the registers. But in the interest of the safety of the articles and the proper registration of them this work must be attended to without fail.

Then the serial number according to the classified registers should be painted indelibly on each article. It will be advantageous to have only one integral number, e.g., 333 or 555. Cumbersome numbering as for instance 494/1937-38 × - (6) should be, as far as possible, avoided. Care must be taken to paint or write the accession numbers neatly on the articles in places not visible to the observer's eyes. Painting the numbers indiscriminately on any part of an article must be avoided. For the sake of convenience the accession numbers may be painted at the left hand bottom corner of the articles wherever possible.

Storing of antiquities.—The storing of stone objects such as sculptures is comparatively easy. They may be kept either in a simple shed or better provisionally displayed in the open air on suitable platforms. There are however sculptures made of such soft stones as marbles and soap-stones which should be carefully watched as even a slight dashing or rubbing against them will cause them irretrievable damage.

Metal objects in general and articles made of precious metal in particular should be stored in very strong rooms. This has to be done in view of their great antiquarian value. Small articles like coins, medals and jewels may be kept in safes while bigger articles such as bronzes may be kept either in almirahs or in racks or simply on the floor. Their safe custody may be the responsibility of more than a single person. Periodical checking, at short intervals, must be done just as the daily checking of the balance of the Permanent Advance in an office. This will prevent the loss of memory regarding the location of even the smallest piece as well as help the custodians to attend to the proper preservation of articles immediately. Storing of pottery, beads, bricks, etc., is also not very difficult.

Paintings, prints and manuscripts will present a problem for storing. The two former items should be kept in such a way as to make an examination of them item by item easy. They should not be spread in a manner which makes them bend, warp and roll. Any one of these defects will cause damage to a painting or a print.

The best way of storing them would be to keep each of them in a glass-topped drawer, several vertical series of which being arranged in cup-boards.

Textiles and similar articles may also be stored in the above manner.

Treatment and Preservation.—The specimens kept in store and those on show are likely to be affected by a variety of factors such as atmospheric effect, dust, frequent handling, heat, light, and insects. So, the specimens must be examined at regular intervals and defects, if any, removed at once. Even specimens of stone and metal are affected. The case of the affected specimens of antiquities should be examined by a chemist well versed in the treatment of such objects. The methods employed for this purpose are dealt with in Section VII of this book. There are three chief methods of cleaning and treatment of exhibits. They are the mechanical, chemical and electrolytic. The former two are employed for simple treatments while the electrolytic method is employed for the treatment of highly corroded metallic objects. The stone articles which show signs of decomposing due to saline action, etc., are treated with paper pulp. Anyway the work of treatment and preservation of antiquities including fragile objects and paintings is a specialist's job.

Display.—Something has already been said about the display of antiquities, their photographs, and charts relating to them. Various effective methods are known to be in vogue in the museums of the countries which are prosperous. In poor countries and in the institutions with little or no resources, experimentation of display can be conducted only to a limited extent. If sufficient resources are available, experiments can be done till a satisfactory arrangement is devised. Here an analogy may be given. In a marriage, the most important thing is the ritual of wedding. The other items of expenditure will be great or small according to the wealth of the parties concerned. Similarly, a museum should always concentrate upon the collection of significant articles and their preservation. According to the availability of resources the whole collection or a part thereof may be put on show. Whatever may be nature of exhibits, their proper display, however, will always enhance their worth, and raise the prestige of the institution because of its popularity with the people. Consequently more and more people will derive the benefits for which the institution is intended.

In the case of specimens of art and archaelogy, it is better that experts in showmanship are entrusted with the designing of galleries and the display of exhibits. They should, however, be in constant consultations with the specialist.

As has been said above, the chief things to be borne in mind in display are the following :—

(1) Restrict the exhibits, in each section, to the minimum.
(2) Show only the best and the most characteristic of a group.

(3) Allow enough elbow-room to the visitors.

(4) Put up exhibits at eye level.

(5) Put up proper but not obtrusive labels at an insignificant but convenient spot against each exhibit.

(6) Have pleasing neutral colour backgrounds for the exhibits.

(7) Take precautions against natural enemies of exhibits.

(8) Provide seats in the section for visitors to sit and examine the exhibits leisurely.

(9) Have sections of moderate size to minimise the fatigue that would be caused to the visitors.

(10) Between two sections provide a small room with its well painted with pleasing colours, and place there a few pictures of great beauty, a few items of furniture and a few flower pots with sweet-smelling flowers. These things will not only relieve the fatigue of the visitors but also make them feel fresh while examining the exhibits in the adjacent section.

Labelling. -Labelling of exhibits displayed in the galleries and those kept in store, is another important item of work of a museum curator or keeper. The gallery exhibits should have, as mentioned above, general labels and labels for individual items. The general label should be precise and contain all the information pertaining to a group of exhibits. Individual labels should be very brief but contain all the relevant information such as the identification, school, period, material and the provenance. They should be in a neutral colour and should be displayed in a corner so as not to distract the attention of the visitor from his appreciation of the antiquities without the aid of any label. This must be the rule in the case of works of art such as sculptures, bronzes, paintings and carvings of wood, etc. Similarly the collection kept in the reserve should also be provided with labels so as to identify them easily.

Lighting.—Besides labelling, the exhibits should be properly lighted. There are two distinctly different views in the matter. Some say that in a tropical country like India, with plenty of natural light, it will be useful to utilise the natural light itself for the purpose of illuminating the exhibits, without resorting to arrangements of artificial lighting, involving a lot of initial expenditure not only in respect of electrical fittings but also in respect of adjusting the architectural designs of the galleries. Others say that in these modern times, when advancement in technology has reached a high level of development, controlled artificial lighting of a suitable type may be employed for the purpose. They are also of the view that this process will be less costly in the long run than the cost of adapting natural light for this purpose. Further, they say that the natural lighting will have adverse effects on the exhibits particularly on such exhibits as paintings, textiles, leather work, and so on. Since most of the museums in India do not yet possess enough resources to set apart a big portion of them for artificial lighting, they cannot but depend on the natural light for lighting the exhibits.

In the case of artificial lighting, the lights and their fittings should be invisible, allowing the light alone to fall on the exhibits.

Guide service.—Despite the excellent methods of display, labelling, etc., the meaning and the educational value of the exhibits in a gallery require to be orally communicated to the visitors especially to the illiterates, by intelligent, well-equipped, and enthusiastic Guides possessing pleasing manners. Only then the visitors will be able to grasp the full import of the exhibits. The Guides, for their part, should only guide the visitors into the mysteries of the displayed antiquities, by speaking gently and plasantly, and to the minimum, to the visitors. The Guide's chief aim should be to kindle in the visitors a desire to learn and profit directly from the exhibits, charts, etc., and to sustain that interest in them rather than to parade his information.

Posters, pamphlets and picture post cards.—Some of the chief instruments in the hand of the Guides mentioned above are these. Effectively and invitingly designed posters hung at the entrances to the galleries of a museum will attract the visitors to the institution. Similarly, attractively got up folders with picturesque and colourful reproductions of at least a few of the outstanding exhibits in the museum and containing the list of the whole lot in bold print should make the visitors examine the items and understand their meaning efforttlessly. At the end of their visit, visitors would like to take with them something, books or reproductions, as mementos. This should be supplied by means of beautifully made picture postcards, preferably in colour, of a few masterpieces, sold at as low a rate as possible so as to make them available even to the poorest class of visitors. The Guide's duty is to introduce naively these things to the visitors. This is one of the very essential services rendered by the Guides, because these aids are to the mutual benefit of both the visitors and the institution. The visitors get enlightenment and satisfaction through these and will tell their people and friends about them. Even if they do not tell anybody about the importance of the museum, a mere sight of these aids in their hands will make their associates curious about the actual exhibits and the institution where they are kept. Supposing, everyday ten of the visitors to the museum take with them, when they go away, folders and postcards and show them, each at least to two of his or her friends, the total number of persons in whom a desire for seeing the museum is kindled works out to twenty for a day. This twenty multiplied by about 300 working days in a year works out to 6,000. Thus in a year at least 6,000 people become really interested in the museum. This is plain arithmetic. This number will be greater as years pass by.

Apart from these folders and postcards, pamphlets containing a little more of reading matter about each group of exhibits should be made available to those who want it and who can afford it.

Research publications.—For all the various types of guiding aids mentioned above, the foundation is the research and comparative studies of the different groups of antiquities and works of art. In fact this is the most important aspect of the whole museum work. It helps the retention of useful items for display, the storing of surplus items and the discarding of the items which are of little or no use. It helps the display of exhibits in any one of the intelligent ways of grouping such as chronological, typological, iconographical and regional. It helps providing easy facilities for academic pursuits in these subjects. So, the museum men should first and foremost be specialists in one or more branches of the subject with which they are dealing. The manner of development of the various sides of the museum work as such which depends on various factors like the availability of funds, buildings, and staff can be learnt in course of time, by the museum men. In the case of wealthy institutions, the museum men who are experts in their own lines need hardly bother about the museum activities as such, as these can be safely entrusted to the hands of experts in the various aspects of these activities such as designing of the galleries and lighting.

The results of the researches of the experts which form the fundamental basis of museum artivities should be published as and when they are available. In these publications the reproductions of photographs of antiquities must be good; but the reading matter is, however, very important. If there are a number of such publications to the credit of a museum, that museum automatically becomes well known in the world because more people will benefit by knowing about the contents of the museum through these publications even though they cannot see them personally. In this respect it is the publications on the museum exhibits that are important rather than the window-dressing of the museum. Although the show cannot be said to be non-essential yet window-dressing is not all important, at any rate it is not certainly as important as the research publications. Window-dressing helps to hide the inadequacy of good material while publications broadcast the glory of the collections of a museum and serve as instructions in so far as the subjects with which they deal, are concerned. The memory of a beautiful window-dressed gallery may be short-lived while a mere knowledge of the existence of the world famous Tiruvalangadu Nataraja in the Madras Museum leaves an indelible impression in the minds of those who are interested in it. Further, knowledge and appreciation of window-dressing will not make any visitor an iota more learned after he completed his visit of the museum than before he entered it. On the contrary, the knowledge about the Nataraja that a person living in a remote corner of the world, who has no hopes of visiting the Madras Museum, derives through the books on it, opens out to him vast vistas of Indian culture and philosophy as embodied in this bronze piece and the beauty of the figure gives him an idea of the heights to which the plastic art of India has reached centuries ago.

Popularisation of the Museum—Announcement of recent additions.—In order to make the people constantly aware of the utility of a museum and the practical services to the cause of education that it renders, it is very essential to forge ties of friendship with the Press and the radio, universities, colleges, learned bodies, leaders of men and intellectuals. Of all these agencies it is the Press that is the most important friend of a museum keeper. Immediately after the addition of a significant specimen to the collections, its proper value has to be found out and a popular but instructive note prepared and sent to Press, especially to those papers which cater to large sections of the people, and wide publicity sought. The editors of such papers should be made to render this help in the interest of education and spreading of knowledge.

Special articles—Besides these short periodical announcements, museum curators should contribute to the Press special articles in popular language on an important specimen or a group of specimens in order to rouse the interest of the reading public in these subjects.

Radio broadcasts.—Similarly, the next most important vehicle of public expression, namely, the radio should be wooed and its medium obtained for publicising the recent additions to the museum's collection and for broadcasting talks on special features of the collections or of the useful services that the museum renders to the people.

Association with Universities, etc.—The museum keeper should be actively associated with educational institution like a university or college and learned associations by bringing the value of the contents of the museum before scholars and learned men for discussion. Professors in the subjects with which the museum deals, may be invited to deliver lectures at meetings organised by the museum. Every opportunity of the visit of experts from other parts of the country or from abroad to the locality should be availed of and arrangements made to listen to their talks bearing on their approach and the results achieved through it, to the various branches of the subjects pursued in the museum. This will enable the acquisition of popularity for the museum in all parts of the world.

Publishing bulletins.—Such deliberations and learned discussions as mentioned above are always of great interest both to the specialists and to laymen. So the publication of the results of such discussions in the form of bulletins in quick succession will be another useful means of popularising the museum.

Special exhibitions.—Things acquired may sometimes have to be stored up in resreve for want of space for their exhibition in the galleries. As almost all the acquisitions are new and must be of some interest or other to the public, it is not enough to give verbal publicity to them through the Press. It is essential that they are properly prepared for display and put up a special exhibitions

running for a stated period of a fortnight or a month before they are stored. A brief announcement should be made in the Press setting out the salient features of the show. Besides, efforts should also be made to send special invitations to the authorities of schools, colleges and learned bodies and even to individuals who are friends of the museum and who are known to be interested in the articles put on show.

Mobile exhibition.—An extreme but an effective step in popularising the museum is to have mobile units of exhibition intended to cater to the people inhabiting the remote nooks and corners of the locality as well as to the people of the nearby towns and villages. The theory on which this method is based is similar to the idea of *bringing god to the doors of the people.* The taking out of images or pictures of gods and goddesses in procession is based on this idea, because such processions are intended to enable the weak and the deformed, the maimed and the lame to have darshan of the Lord's image when the procession goes through the streets where these people live. Similarly, to give the benefit of the knowledge of antiquities to such classes of people and others of similar category, the mobile exhibitons are very essential. Although every museum cannot afford to provide for this, yet such of those as have plenty of resources should have this method of popularising the museum as an important and integral part of their routine.

Excursions to historical places.—Another important means of popularising the museum of art and archæology is to assist in taking out excursion parties of people to places of artistic and archaeological interest situated in the neighbourhood of the town or locality where the museum is situated.

Administration.—To attend promptly to the above mentioned activities, the museum-keeper should have a group of efficient assistants including an office-manager, store-keeper, accountant, stenographer, clerks, photographer, duffadar and peons. All public correspondence should be promptly attended to. The museum-keeper should always be on the alert to acquire funds and in the speedy acquisition of exhibits. Steps must be taken quickly to get the required items of furniture, etc., made. Proper arrangements should be made to supply the demands of photographs to visitors. Bringing out the publications mentioned above must be an important routine and no efforts should be spared to print new editions of books that are being exhausted. Tools, instruments and other materials required for day-to-day work must be constantly examined and fresh ones purchased whenever there is a need for them.

The staff of the museum should be kept contented, because the maintenance of the show-rooms and benefits that accrue to the people at large through the show, rest solely on the willing, enthusiastic and intelligent work of the staff. It is therefore of prime

necessity to secure the full co-operation of the staff by all possible means. When their wants are satisfied and respects due to them given the staff naturally dedicate themselves to their noble work.

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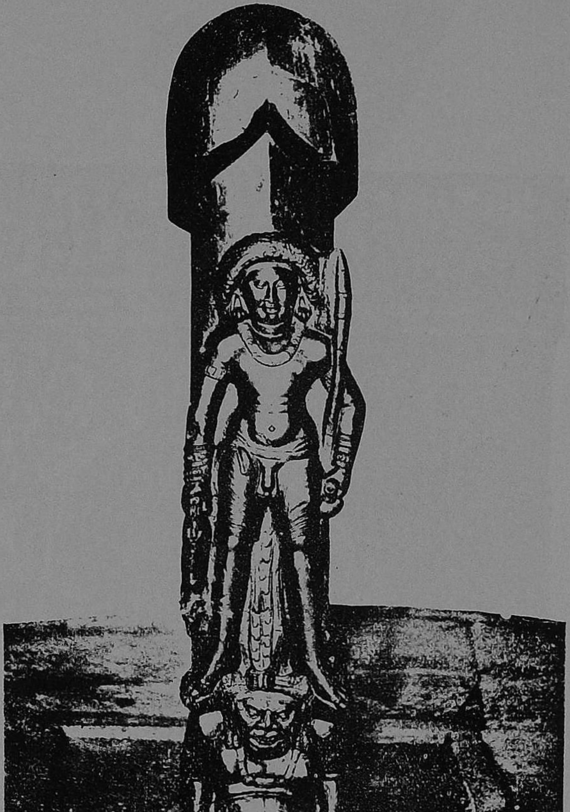
PLATE I.

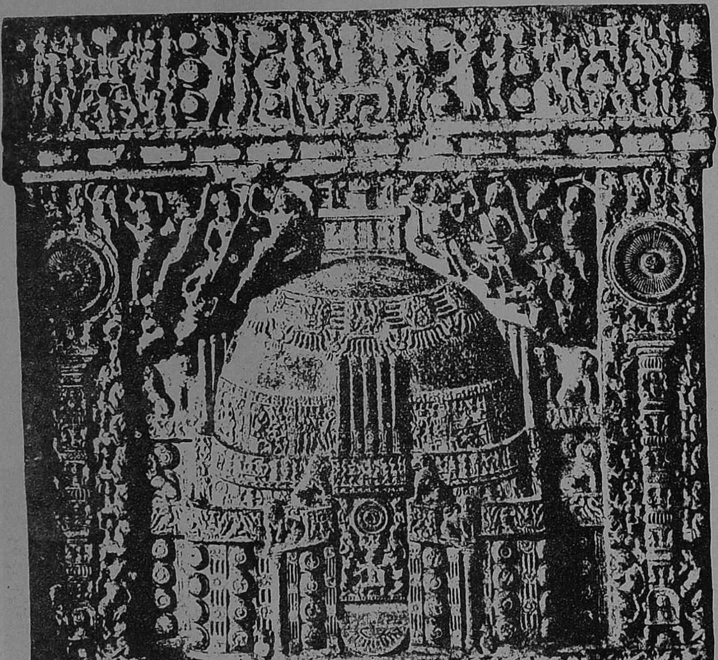
DIDARGANJ YAKSHI.

PLATE II.



GUDIMALLAM SIVA LINGA.

PLATE III



STUPA SLAB FROM AMARAVATI.

PLATE IV.

BUDDHA. GUPTA PERIOD FROM SARANATH.

PLATE V.

BHIKSHATANA FROM BHIKSHANDARKOIL.

PLATE VI.

RAMA FROM VADAKKUPPANAIYUR.

PLATE VII.

NATESA FROM PUNGANUR;

SECTION VI.

Man and His Cultural Beginnings.

By C. J. JAYADEV, M.A., L.T.
(Assistant Superintendent, Government Museum, Madras.)

I. Introduction.—Anthropology is the subject which specially studies primitive and ancient man. It is conveniently studied under three of its main aspects which are closely interrelated. These are the historical, biological and sociological aspects. (1) The study of Early man and his works is spoken of as *Pre-history* or *Pre-historic Archaeology*. All the remains of past civilisations of the stone, bronze and iron ages are included in this study. (2) The biological study of man and his relationship to the animal world is based on the principle of evolution. His relationship to several extinct species of men, ape-men and man-apes and the extant species of apes based on structural features form the content of this science which is termed *Physical Anthropology* or *Human Biology*. (3) The study of man as a social being, his manners and customs, knowledge of arts and industries, his material and moral culture, tradition, social structure, language, religion, etc., is termed *Social* or *Cultural Anthropology*.

II. Pre-history is divisible into certain definite ages each of which is characterized by a certain level of culture of ancient man. Thus in the *Old Stone Age* or *Palaeolithic* time man was at best a gatherer and collector of readily available food. He made weapons and tools of stone, antler, bone and wood and used them for digging, hunting and fishing. He knew the use of fire and is even credited to have given his dead ceremonial burial. But he had no knowledge of agriculture or the domestication of animals. He did not make or use pottery. Large collections of quartzite implements found in the lateritic formations of Chinglepur, Nellore and Kurnool districts are examples of this culture of early man in South India. These stone tools are roughly chipped and flaked. This palaeolithic culture is believed to belong to the *mid-Pleistocene* period in South India.

During the next period, the *Neolithic* age, man is no longer dependent upon food-gathering. He has discovered the use of agriculture and domestication of animals. The making and use of pottery is also considered to be a feature of the Neolithic peoples. Instead of the roughly chipped and crudely fashioned quartzite tools of the Palaeolithic he had more or less perfected the art of stone tool manufacture. The stone tools were also ground and polished. The large numbers of ground and polished stone implements from the Bellary district which have pointed butt and oval cross-section with a fine cutting edge belong to this period. They

are called celts, and are usually made of trap rock. Side by side with these tools we have a large number of small flake tools of chert and jasper. The agriculture of this period is probably comparable to the shifting cultivation of many of our present day aboriginal peoples.

Settled agriculture is said to have led to the establishment of urban civilizations of the river-valley type, e.g., Nile, Euphrates and Indus. Here the discovery of copper and bronze led to their being used for tools and weapons. Iron was entirely unknown during this *Bronze* Age* when some of the neolithic stone tools persisted side by side with the bronze as is seen at Mohenjo daro and Harappa. The bronze age has also been recognized in South India in Mysore and other places. While the Neolithic in South India is considered to be nearly ten thousand years old the Bronze age is believed to be roughly five thousand years old.

The Early Iron Age in South India is recognized to be over two thousand years old. The large numbers of iron implements and pottery obtained from numerous ancient South Indian burials illustrate this period with which is associated the prevalence of rude stone monuments called *megaliths*. These include *cairns* [1], *cists* [2], *dolmens* [3], and *stone circles* [4]. *The urn-burials* [5] *of* Adischanallur in Tirunelveli District and the *Sarcophagus burials* [6] of the Chingleput and South Arcot Districts also belong to this period. Bronze objects, pottery, beads and chank shell ornaments are associated with these burials.

III. Physical Anthropology or Human Biology deals with the study of the human species and its division into several races. Certain measurements and anatomical characters are considered to be diagnostic of racial groups and among these are stature, colour of the eyes, hair and skin, head, face and nose form, etc. On the basis of these features mankind is divided into certain definite races—*Negroid, Amerind, Mongoloid, Caucasoid and Australoid.* Of these the Caucasoid is again subdivided into *Nordic, Alpine, Armenoid, Dinaric, Oriental and Mediterranean* types. Most of these racial types are represented in the population of India.

Physical characteristics of the races of India.—1. *The Australoids or Veddoids.*—Most of the aboriginals of peninsular India belong to this stock. They have short stature, long heads, prominent eye-brow ridges, broad short faces, flat broad noses, curly or wavy hair, dark brown skin and dark eyes. The Chenchus of Nallamalais and the Veddahs of Ceylon are good examples.

2. *The Mediterraneans.*—This forms the major element in the population of India. They have medium or short stature, longish heads, faintly marked eyebrow ridges, broad, short faces, prominent medium noses, wavy hair, dark or light brown skin and brown eyes. Most of the Dravidian speaking peoples belong to this type.

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1. கல்குத்து. 2. கல்லறை. 3. நடுக்கல். 4. கற்றிடை. 5. முதுமக்கள் தாழி. 6. ஈமத்தாழி

3. *The Brachycephalic Armenoids.*—They have medium stature, round heads with flattened occiputs, long convex noses, brown skin and eyes. The majority of the peoples of Maharashtra, Gujerat, Bengal and Canara come under this racial type.

4. *The Proto-Nordics.*—This racial type is characterized by tall stature, long heads, long faces, prominent narrow noses, light, straight hair and light eyes. These are represented in the populations of Northern India.

5. *The Mongoloids.*—The peoples inhabiting Assam and the eastern borders of India and the cis-Himalayan region belong to this racial type. They have medium stature, often broad, round heads, medium noses, flat faces, dark, coarse and straight hair, yellowish skin, brown eyes and a prominent fold of the upper eyelid on the inner side called the epicanthic or Mongolian fold.

None of these groups can be considered to be pure but are the products of an age old process of interbreeding so that we get all sorts of intermediate racial types, one racial type merging into another. Thus in South India the Veddoids merge into the Mediterraneans, the Mediterraneans merge into the Brachycephals on the one side and the Mongoloids on the other.

IV. Social and Cultural Anthropology.—The study of man as a social being includes two interrelated features—his social organisation and material culture. The manners and customs, beliefs and practices of a tribe or community are closely related to the arts and industries, dwellings, implements used in gathering, hunting, agriculture, war, music, dance, the wearing apparel and ornaments of the tribes. Many of the practices of aboriginal people are explicable only in the light of their social organization and level of culture.

The Kadars of Cochin and Chenchus of the Nallamalais are food gatherers with a digging stick culture. The Kurumbas and Todas of the Nilgiris are pastoral peoples tending their flocks and herds. The Mannans and Muthuvans of Travancore are given to axe cultivation called Podu. The Savaras of the Agency districts are settled agriculturists.

V. Collection of Anthropological exhibits.—*Prehistoric Archaeology.*—The fossil remains of early man and all the objects made and used by him are objects of archaeological interest. Among these are implements of stone, tools and weapons of bronze and iron, utensils and ornaments of bronze, pottery, shell, bone and horn, beads of stone and metal. Most of these antiquities are obtained from archaeological excavations while a fairly large number of them can be obtained as surface finds from ancient sites.

Physical Anthropology.—Exhibits under this head include skull types, models and photographs of the physical types of different races, plaster-cast reconstructions of the various fossil types of early men such as the Ape-man of Java, the Ape-man of Peking, Neanderthal man, CroMagnon man, etc.

Photographs of the aboriginal tribes of South India can be purchased from this Museum at Rs. 20 per set of twenty half plate size prints.

Ethnology.—Exhibits under this head include models of the dwellings of such primitive peoples of South India as Kadars, Chenchus, Todas and Savaras, their dress and ornaments, the implements used by them in digging, hunting, agriculture and fire-making. Musical instruments, objects used in religious worship and writing materials are also included among ethnographic exhibits.

Anthropological exhibits of the following types can be collected by school teachers with the co-operation of their pupils :—

Models.—Models of huts, limekiln, oil-mill. potter's wheel, hand loom, furnace, Persian wheels, etc. Such exhibits can be purchased from manufacturers or constructed. Toys, puzzles, traps, musical instruments, artistically worked pieces of baskersy, cheap jewellery, votive offerings, objects used in various ceremonies, festivals and rituals can also be collected as exhibits.

VI. Preservation of Anthropological museum specimens.—Before commencing the preservative treatment of anthropological exhibits the first essential step is the normal routine of cleaning, dusting and provision of insect repellents and insecticides such as naphthalene and D.D.T.

Four definite stages have to be recognized in the treatment of exhibt—

(*a*) The identification of the object or materials, its nature, classification and labelling have to be attended to first.

(*b*) The nature of deterioration to which the object or specimen is normally subject to and stage at which such deterioration has taken place. This is necesary to vary the nature of the preservative treatment according to its state of preservation. The specimen may be new and quite fresh requiring very little treatment or it may be in a state of decay requiring very careful treatment.

(*c*) The nature of the changes expected on preservative treatment. Here some of the injurious effects of certain processes have to be foreseen and avoided.

(*d*) The actual processes and techniques involved in such treatment and the chemistry of materials and processes. A detailed and practical knowledge of such processes and techniques is essential for the successful preservation and protection of anthropological exhibits

The preservative treatment of anthropological specimens consists in strengthening them and reducing the action of the various agencies tending to their deterioration or destruction. Here considerable care and judgment is to be exercised in determining the nature of the damage or otherwise of the specimen and its effective preservation. A record of previous preservative treatment giving the dates on which such work was carried out and a detailed account of the techniques and processes used in such preservation will be helpful in estimating the state of preservation of a particular specimen.

VII. Special methods in the preservation of Anthropological museum specimens.—A classification of anthropological museum specimens into materials of (*a*) animal, (*b*) vegetable and (*c*) mineral origin is helpful in devising ways and means of their care and preservation.

Among materials of animal origin, are bone, feathers, fur, hair, horn, ivory, leather, shell, silk and wool.

Materials of vegetable origin include bamboo, bark, basketry, leaves, fibres, textiles and wood.

Materials of mineral origin are beads, glass, pottery, plaster casts, stone implements and objects made of metals and alloys such as bronze, copper and iron.

A. Objects of Animal Origin—*Bone.*—Two kinds of specimens have to be distinguished here—

(*a*) Actual skeletal remains whether of human or animal origin are dug up in archaeological excavations, (b) Tools, weapons, carvings and other artifacts made of bone are met with as antiquities or ethnographic materials.

(*b*) Skeletal remains are preserved and strengthened if they are found in a crumbling condition by the use of shellac solution in spirit (2 per cent) or with vinyl acetate solution. The solution is allowed to permeate the specimen before it is completely dug out of the soil.

(*c*) Bone artifacts if met with in a well-preserved condition are cleaned with soap and water and treated with celluloid solution after thorough drying. If the specimens are in a fragile condition cleaning with alcohol is necessary before strengthening.

Feathers.—The dance head dress of many of the Mundari speaking tribes of Orissa and Central Provinces are decorated with peacock feathers. Specimens which include feathers require careful preservation. They tend to become brittle and deteriorate easily. Fumigation with insecticides (carbon tetrachloride, carbon bisulphide, etc.,) and storage along with containers of camphor dissolved in lysol ensures adequate protection. For preservation spraying with a very thin solution or celluloid (about one per cent) is **necessary.**

Fur.—Furs are liable to be attacked by moths. This is prevented by fumigation and protection with the use of insecticides as in the case of feathers. The skin part of the fur tends to become hard and brittle on long storage and the hairs begin to fall out. Under such conditions the skin should be rubbed with small quantities of vaseline or preferably a mixture of castor oil and rectified spirit (1 : 4).

Hair.—Specimens made of hair preserve well in storage. If they become dry and brittle and lose their glossy appearance they may be treated with vaseline in small quantities. The usual protection from insect pests is necessary.

Horn.—Articles made of horn keep well under normal conditions. Cleaning with water is necessary if they become dirty. Greasy specimens can be cleaned with methylated spirit. Drying is necessary before storage. Strengthening of horn specimens can be carried out if necessary with celluloid solution. Horn articles must be carefully protected against insect pests, fungi and bacteria by using camphor dissolved in lysol and naphthalene in storage or exhibit cases.

Ivory.—Objects made of ivory preserve very well in museums. Cleaning ivory specimens with water is not advisable. Old specimens tend to crack and split on being wetted. Alcohol is to be used in such cases. Discoloured or greasy specimens can be bleached and cleaned by using hydrogen peroxide. Liquid soap and celluloid solution is used for strengthening and preservation after thorough drying.

Leather.—Articles made of hides, skins or leather tend to become hard and brittle with age. Such specimens are treated with a mixture of castor oil and rectified spirit (1 : 4). The membranes of drums, strings of sinew used for bows and musical instruments and leather thongs respond well to this treatment. Coating the leather portions of such objects with the mixture is repeated several times if its absorption is slow. The mixture is thinned out with excess of spirit and applied to facilitate absorption. The leather shadow play figures in this museum are given this treatment periodically. This process increases the softness and flexibility of the leather objects and prevents them from becoming hard and cracking up. Leather objects have to be carefully protected from insects, fungi and bacteria.

Shell.—Articles made of shells especially inlay pieces, bangles, rings and other ornaments are frequently met with among archaeological finds. They are usually in a good state of preservation. They can be cleaned with soap and water unless they are in a highly decaying condition. After drying the specimens are soaked into a thin solution of celluloid.

Silk.—The cleaning and preservation of articles made of silk may be carried out much in the same manner as any other textiles.

Wool.—Articles made of wool can be treated in the same manner as other textiles. Great care should be exercised in the protection of woollen objects against moths.

B. Objects of Vegetable Origin—*Bamboo.*—Most of the primitive tribes of South India use bamboo for building their huts, for making household utensils, bows and arrows, fire-making implements, digging sticks and musical instruments.

In the preservation of specimens made of bamboo two kinds of articles have to be distinguished. On the one hand there are large and substantial articles which preserve well. These require treatment in the form of a thin coating of paraffin wax. The wax is melted in turpentine which is warmed on a water bath. The wax dissolved in turpentine is applied uniformly over the specimens. The large models of huts of aboriginal people are also treated in this manner for preservation. The smaller articles are usually made of fine bamboo strips which are woven. Such are mats, baskets, woven utensils, purses, bags, etc. These can be given wax treatment or coated with creosote thinned with turpentine.

Bark.—Objects made of bark and bark fibre are used by many hill tribes as ornaments, utensils and wearing apparel. Paraffin wax dissolved in turpentine is coated with a brush while the solution is warm for the preservation of bark objects. If the objects are small they can be coated with creosote and turpentine.

Basketry.—Being of vegetable origin basketry articles tend to become hard and brittle with age and are to be preserved with care. Paraffin wax in turpentine is a good preservative. Beeswax dissolved in petroleum can also be used instead of paraffin wax.

Leaves.—Articles made of leaves are in common use among many tribal and rural peoples. Rolls of Pandanus leaves are used to dilate the pierced opening of the ear-lobes. Some hill tribes formerly used to wear leaf aprons. Palm-leaf cadjans are still used for writing on with steel styles. Many household articles such as mats, screens and baskets are made of leaves. Such articles are best preserved by giving them a coating of wax melted in turpentine. Creosote in turpentine may also be applied.

Fibres.—Plant fibres are used for making bags, nets, ropes and slings. Articles made of fibres are best preserved by treating them with paraffin wax and turpentine.

Textiles.—Cotton textiles preserve well if protected from bacterial and fungal infection. They are, however, subject to decay by a process of slow combustion. If the specimens are fresh and strong they can be cleaned and washed with soap and water. Care

should be taken to see that such wet cleaning is not likely to remove dyed or painted designs on them. Dry cleaning with petroleum or alcohol is preferable especially if the specimen is dirty or greasy. A solution of alum and gum arabic strengthens textiles and freshens up their colours. Thorough drying and storage protected by camphor dissolved in lysol and naphthalene protects them from fungal and bacterial action.

Wood.—Enthnographic collections include a large number of articles made of wood. Household utensils, implements used in agriculture, hunting, digging and firemaking, ornaments such as combs and ear discs, musical instruments and many toys are made of wood. Articles made of wood preserve well if protected from insects and fungi. The preservative treatment consists in coating the specimens with paraffin wax dissolved in turpentine. Repeated coats are to be given so as to ensure permeation of the wax into the porous portions of the wood. Creosote is also an excellent preservative of wood. It has to be applied in the pure form or diluted with turpentine. Wood carvings can be preserved by coating them with varnish and linseed oil. Ascu treatment is also effective in protecting wood carvings from destruction by insects or fungi.

C. Objects of Mineral Origin.—Beads made of agate, carnelian, chalcedony, quartz or other mineral stones require practically no preservative treatment except cleaning and washing with soap and water. Usually beads have their perforations clogged up with soil or dirt and this is cleaned with needles. Glass beads can be treated similarly. Beads of terra cotta sometimes require strengthening. This is done in the same manner as the strengthening of pottery (vide pottery). If beads form a series, they can be strung together on a piece of thread. Broken beads can be repaired with celluloid cement if the broken pieces are fairly large and few.

Glass.—Antiques of glass can be cleaned with soap and water or methylated spirit. For mending broken specimens celluloid cement should be used. Glass articles which show signs of devitrification should be treated with one per cent sulphuric acid immersed in alcohol and coated with dilute celluloid solution after drying.

Pottery.—In the treatment of pottery the following steps are to be recognized. Cleaning, removal of soil incrustations, strengthening, repairing and restoration.

Cleaning should not be attempted in the case of painted pottery unless it is made certain that such cleaning would not affect the painting.

(*a*) *Cleaning.*—Repeated soaking in water is advisable if the pot is in good condition and is not likely to be damaged by water. Coarse pottery and pots which are not well-baked are likely to be

destroyed by treatment with water. In such cases strengthening alone is enough. Soaking in repeated changes of water removes salts which have permeated the pots and may damage them.

(*b*) *Removal of soil incrustations.*—Many pots which are dug out of the soil have soil incrustations of calcium carbonate which are unaffected by soaking in water. After cleaning with water the pot is soaked in five per cent hydrochloric acid. The acid is applied from time to time and the pot washed in water.

(*c*) *Strengthening.*—When pottery specimens are in a crumbling condition strengthening them is necessary. Such specimens should not be cleaned with water or treated with dilute acid. They have to be kept dry and a thin two per cent solution of shellac applied to them repeatedly by means of a paint brush till the solution permeates the entire pot. This treatment has to be repeated at intervals and the pot stored after drying.

(*d*) *Repairing.*—Pottery specimens usually break into pieces on their being dug out of the soil during excavations. Very often entire pots are broken in transit on account of bad packing. In such cases the broken pieces or potsherds have to be collected together and stored together. The arrangement of the broken pieces together for repairing resembles the fitting together of the pieces in a jig-saw puzzle. The broken bits have to be carefully cleaned and assembled. A mould or prop of plasticine is useful in assembling the pieces together. The broken edges of the potsherds are smeared with a thick shellac cement and held together to dry. After drying the mould or prop is removed. If all the pieces could not be held together the mending work can be carried out in parts. The basal pieces are first joined together. This is followed by the body and finally the rim pieces are put together.

(*e*) *Restoration.*—In repairing broken pottery it will be found that small pieces are missing leaving gaps in the pot when mended. Such gaps are usually filled up by means of plaster of Paris casts made to resemble the lost potsherd in that position. To carry out such restoration a mould is made out of plasticine and propped up against the gap into which the mixed plaster is poured and the excess is removed by scraping off before it sets hard. The parts restored are allowed to set and dry thoroughly and then painted over to match the colour of the pot.

Plaster cast models.—Replicas of rare antiquities, fossils, biological specimens, etc., are made of plaster of Paris. Some antiquities are made of alabaster. These are fragile and should be carefully handled. They are often broken in transit. Repairing plaster casts can be carried out by joining the broken pieces together with plaster of Paris or celluloid cement. Cleaning of plaster casts except for routine dusting and brushing is not advisable. Occasionally they may be cleaned with methylated spirit.

Stone implements.—Artifacts made of stone require practically no attention as they preserve very well. Cleaning with soap and water is sufficient. Mending of broken tools with celluloid cement is recommended.

The preservative treatment of metal objects, especially bronze, copper and iron articles is dealt with under the section of "Chemical Conservation" in this handbook.

Appendices to this section include a list of chemicals required for the preservation of anthropological museum exhibits.

APPENDIX I.

CHEMICALS USED IN PRESERVATION WORK

Acetone.
Alum.
Amyl acetate.
Beeswax.
Camphor.
Carbon bisulphide.
Carbon tetrachloride.
Castor oil.
Celluloid.
Creosote.
Gum arabic.
Hydrogen peroxide.
Hydrochloric acid.
Naphthalene.
Paraffin wax.
Petroleum.
Plaster of Paris.
Plasticine.
Shellac.
Spirit—methylated
Spirit—rectified.
Sulphuric acid.
Turpentine.
Vaseline.
Vinyl acetate.

APPENDIX II.

THE LOCATION OF PRE-HISTORIC OR ARCHÆOLOGICAL SITES.

Surface indications often give the clue to the existence of archaeological or prehistoric sites. At the sites of prehistoric habitations, stone implements, potsherds and beads may be found on the surface. In connection with prehistoric burial sites huge stones, large sherds of urns or other burial pottery, iron implements, chank shell ornaments and beads may be found. At historic sites such remains of buildings and walls as sculptured stones or large bricks may be found in an unusual setting. An archæological site overgrown with natural vegetation may often present definite patterns on its appearance. At certain regions corresponding to buried buildings or walls the vegetation would be sparse or absent while in the surrounding regions it would be abundant and dense. This is often very clear in aerial views.

APPENDIX III.

SITES FROM WHERE PREHISTORIC STONE IMPLEMENTS COULD BE COLLECTED IN SOUTH INDIA.

Madura	Shingle beds in the alluvium of the Vaigai on the left bank immediately north of Madura town.
Tanjore	Laterite deposit lying to the south east of Vallam and south-west of Tanjore town.
Tiruchirappalli	Laterite forming plateau East of Ninniyur, 45 miles north-east of Trichy town.
Bellary	Surface of the shingle fans along the foot of the copper mountain south of Bellary town. Also from Halakundi shingle fans.
Cuddappah	Thin spreads of laterite gravel in Rayachoti taluk.
North Arcot	Laterite gravels.
Chingleput	Boulder conglemerate at Vadamadarai in Korttalaiyar valley; laterite conglomerate of Attirampakkam.
Nellore	Laterite gravels resting on the gneissic rocks in Maneru valley. Laterite pebble bed in Bhavanasi gravels at Krishnapuram on the Atmakur Dormala pass on the Rallu vagu and Yerrakonda-palem, on the bank of Sagileru at Giddalur near Nandikama pass.
Kurnool	Valley of Khunda near Roodrai in laterite gravels.
Guntur and Krishna ..	High level gravels at Ippalam and Oostapalli.

APPENDIX IV.

ADVISORY INSTITUTIONS.

Teachers and others who are interested in building up school museums and similar institutions can obtain special advise and help in the collection of anthropological museum specimens from the following:—

1. Superintendent, Madras Government Museum, Madras-8.

2. Director, Department of Anthropology, Indian Museum, Calcutta.

3. Director-General of Archaeology, Archaeological Survey of India, Curzon Road, New Delhi.

APPENDIX V.

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SECTION VII.

Chemical Methods of Restoration and Preservation of Museum Exhibits.

By R: SUBRAMANIAN, M.A., F.I.I.C.

(Formely Curator, Chemical Conservation Section, Government Museum, Madras.)

Introduction.—The application of chemistry to the field of Art and Archaeology is one of the recent developments of science. Archaeologists encounter various types of materials, both organic and inorganic, during excavation which are in a state of partial or complete disintegration and they need the co-operation of chemists for the restoration and proper preservation of these materials. It is indeed gratifying to note that a number of foremost men in chemistry have been devoting great attention to this subject recently and several definite conclusions have been arrived at as the outcome of their admirable studies and experiments.

No less important has been the bearing of chemistry and physics in settling various disputed points. Applied chemistry has been the crucial means for the detection of frauds or the establishment of authenticity. James J. Rorimer of the Metropolitan Museum of Art has developed a method for the detection of the age of marble objects. "Under the ultra-violet ray old marble is different from freshly cut marble and from old marble which has been recut." "In several cases it has been possible to demonstrate conclusively that certain objects of art had been rather recently repaired, the new inserts showing up in strong contrast with the original stone". X-rays and ultra-violet rays have been of great use in studying the various layers of paintings—the ground (canvas or panel), the priming layer and the paint layer. Each has a particular absorption for these rays and is reproduced in the photographic image in its characteristic manner from which the critic can draw conclusions. Radiographs also indicate how much of metallic core is left behind in a highly corroded object and the feasibility of undertaking the cleaning process.

Hundreds of chemical analyses carried out on antique materials have put archaeological data such as date and locality on a firm ground. It has been shown for example that the metal in the iron objects of the Le Tene period in Switzerland came from the mines of Tuscany. Microscopic examination of coins and metallic objects reveal their internal structure and the patterns obtained indicate whether they had been cast or worked or both. In recent years the sensitivity of microchemical tests has been greatly increased, eliminating the necessity for taking large samples from valuable antiquities. Electrochemical analysis has been yet another means in this direction.

Restoration and Preservation.—The aim here is to give in broad outline some of the methods that are employed in the restoration of particular materials. For full details the books listed at p. 220 *et seq.* may be referred to.

Before undertaking the actual cleaning of any antique object, certain general points have to be noted. It must be remembered that the materials upon which the experiments are made are frequently of great value. All cleaning processes take time and restoration work should never be hurried. "It should not on the other hand be set aside for long periods when once begun". The great urge to resort to crude mechanical means in removing hard crusts should be fully arrested. A close examination of the material is in all cases necessary. In some cases the antiquities would have undergone very little deterioration calling for no drastic treatment while in some others the disintegration would have progressed to such an extent that it would be unsafe to undertake any restoration. Conservation and not restoration should be the foremost point in such cases. It is not uncommon that all that is left out of an ancient iron object is just a mass of rust. Lastly if there is the least shadow of doubt about the safety of using a particular reagent, it is well to determine by careful experiment the effect of the reagent on a small portion in an odd corner of the specimen.

(1) Copper and Bronze.— The most frequently occurring objects which need restoration are of copper and copper alloys. Bronze is an alloy of copper and tin. Ancient bronzes vary considerably in composition. They range in composition from those containing 5 per cent tin or less to others which contain as high as 30 per cent. The hardest bronze contains about 12 per cent tin; a higher percentage makes the metal brittle. Some of the bronzes also contain a little lead and zinc besides traces of several other elements. The nature and degree of deterioration suffered by an object depends upon various factors : (i) the composition of the alloy, (ii) mode of smelting and the original manipulation of the components such as good or poor mixing, fine or coarse grains, etc., (iii) the porosity and the character of the soil in which the alloy has lain, (iv) the galvanic action with other metals, (v) contact with organic remains, (vi) the length of time during which the object has been exposed to the particular conditions. Among the salts found in the soil which are responsible for the decay of metals and alloys are the chlorides and nitrates of sodium and calcium and the sulphate of calcium. The bronzes are gradually attacked giving rise to green, blue, brown and red crusts. Copper is changed into the oxide, chloride, oxychloride and carbonate; tin is converted into oxide. Occasionally sulphate and sulphide are also found. In the case of bronzes whose alloy had been homogeneous, fine-grained, dense and not porous and whose surface had been so smooth that the process of disintegration could proceed only very slowly, the corrosion products are formed in such a way that the contours of the

bronzes with all their markings are distinctly visible. The surface film—the patina—is thin, smooth, hard and enamel-like in appearance. The colour of the patina may vary greatly. It may be bright green, blue or of darker shades. Such a type of patina, otherwise known as " noble patina " or " edel patina ", protects the metal beneath and should not be interfered with. Such bronzes call for no treatment beyond simple cleansing. But this type is rare, and what is commonly met with is a rough, porous type of uneven thickness, containing in some cases calcareous dirt, and exhibiting great outward deformity. Sometimes, an object otherwise in good condition, shows green spots which are of a very dangerous character. The usual cause of this is the presence of traces of chlorides and the action is mainly electrolytic. The spots grow in size, sometimes slowly and sometimes rapidly and continue the destructive action indefinitely. This type of corrosion has been termed " the bronze disease " and the green spots are known as " malignant patina ".

The main problems with the bronze objects are—(i) to remove the disfiguring incrustations which conceal the decorative details, (ii) to restore to the object its original appearance and (iii) to eliminate the corrosive substances which cause the rapid disintegration and thus to assure the permanence of the exhibits. Various methods have been developed for the restoration of these bronzes *. There is no universal treatment applicable to all objects and experience is the only guide in arriving at the proper decision.

The restoration methods may be grouped under three categories :—(*a*) electrolytic, (*b*) electrochemical and (*c*) chemical. There has been some controversy about the advantages and merits of one type over the others. The restorations carried out in the chemical laboratory of the Madras Museum during the past ten years have shown that, in point of safety and the accuracy with which the hidden details are brought out, the electrolytic method is unequalled by others. This method is being regularly used by the Field Museum of Natural History, Chicago, Museum of the University of Pennsylvania, Fogg Art Museum of the Harvard University and other American Museums.

(*a*) *Electrolytic Method.*—The electrolytic process which is the reversal of the process of corrosion was first suggested by Finkener, Ch. Frisch, Francois Margival and Francesco Rocchi. It was Colin G. Fink who worked out the experimental details for the first time. The apparatus used is much like that employed for electroplating. Without any preliminary cleaning, the bronze object to be treated is hung as cathode in a 2 per cent caustic soda solution. (Commercial grade of caustic soda in flakes is used; if the sample is damp and in lumps, it is rejected lest the carbonate present in it should damage the valuable bronze). The object is suspended with copper wires and is completely immersed in the solution. Iron wire gauze or sheets hung on either side serve as the anode. (In the Madras

* These methods are also applicable to objects of copper and other alloys of copper.

Museum cylindrical iron tanks with welded joints are used as anodes. A glass trough of suitable dimensions serves well as a container. (For large objects glazed earthernware tanks are used). The current required can be tapped from some kind of primary battery such as three or four Daniell cells (in series) or from two accumulators (in series) or from the mains (should be *direct current*). Other primary batteries can be used, but Daniell cells are recommended on account of the steadiness of their action. The negative pole of the battery is connected to the bronze (cathode) and the positive pole to the iron anode. If there is any doubt about the polarity, moisten a small piece of filter paper with a drop of solution of potassium iodide and touch the two conducting wires with it simultaneously. A brown spot will be seen on the paper at the point of contact with one of the wires; this is the positive wire. (Filter paper moistened with 'sodium chloride and phenolphthalein' may also be used. In this case the pink colour produced indicates the negative pole.) Sometimes due to the resistence of the crust, current will not flow easily at first. So it is best to immerse the object in the solution at night, allow the solution to penetrate the crust slowly and start the electrolysis the next morning. The optimum current density is one ampere for every 20 sq. in. of the surface treated. This means that for a small object of about 10 sq. in., only 0·5 ampere is required.

The action of the electrolysis is to evolve hydrogen at the cathode (bronze) and reduce the crust to finely divided copper. The reduction of a thin crust (1/16th to 1/8th inch thick) requires 3 or 4 days. It is advisable to renew the electrolyte once or twice. The reduction is complete when all the chlorine (and other radicals) previously combined with the metal, has combined with the hydrogen produced by the electrolysis. There being no further chlorine with which the hydrogen produced by the continued action of the current may unite, the completion of the process is indicated by the free evolution of the gas at the cathode even with very low current densities. The object is then removed from the solution, well washed in running water and then soaked in repeated changes of water for several hours. The final washings must be done in repeated changes of distilled water. Between the soakings, the object is gently brushed with a soft tooth brush. (Fine brass-wire brushes may also be used when necessary). The last washing when tested with silver nitrate should show no turbidity. The most frequent cause of failure is 'inadequate washing' and the inevitable result is a perennial struggle against fresh attacks. "Too much stress cannot be laid upon the necessity for thorough washing which as a rule means soaking the object for several days in repeated changes of water"

After thorough washing, the bronzes are dried at once and as quickly as possible. They should be wiped with soft cloth and then dried upon metal rings over a stove. Small objects may be freed from water by immersion in alcohol for 24 hours before drying.

The bronze is finally given a preservative coating to protect it from internal influences. Various substances have been used for this purpose. O. A. Rhousopulos employs the following method: "The object is heated upon a metal plate by a fire or gas or spirit lamp. The object whilst still warm is rubbed with a brush which has been stoked over pure wax and this process is repeated until the bronze has received an extremely thin layer of wax". Molten paraffin wax may also be applied by immersing the object in it. Alternatively the object can be coated with a solution of paraffin wax in benezene (5 per cent) by means of a brush. Two or three coats of either a solution of vinyl acetate in toluene (2 per cent) or of celluloid in equal parts of acetone and amyl acetate (2 per cent) can also be given.

(b) *Electrochemical Method.*—In this method the object is kept in contact with a suitable metal such as zinc, both being immersed in acid or alkali. The mechanism of the reaction is very complex —mechanical, chemical and electrochemical.

The bronze is first given a preliminary cleaning by soaking in repeated changes of water to wash away the soluble salts.

Take an enamelled iron vessel and shake into it a layer of granulated zinc. Place the object over that and spread more zinc granules so as to cover the object completely. Add enough of a dilute solution of caustic soda (10 per cent) so that the object is completely under the solution. Heat and allow it to simmer gently. A rapid evolution of hydrogen takes place and reduces the crust.

The object is removed after 24 hours and brushed. The process is repeated, if necessary. The solution is renewed every time but the same zinc may be used again and again after washing in running water. Instead of using granulated zinc the object can also be wrapped in strips of zinc. Some alloys are more responsive to acid reduction than to alkaline reduction. In such cases 5 per cent sulphuric acid can be used in place of caustic soda.

The object is washed well, dried and given a preservative coating. Rhousopulos who has used a similar method with great success for the restoration of Egyptian bronzes and those from the Akropolis and Anticythera, says: "The process is characterised by its simplicity, thoroughness and sure, exact, smooth working. This method can be applied to the largest object without difficulty or cost worth mentioning".

(c) *Chemical Methods*: (i) *Rochelle Salt Method.*—The alkaline rochelle salt solution required for the process is prepared by dissolving 15 parts by weight of rochelle salt and 5 parts by weight of caustic soda in 100 parts by volume of water. The object is kept immersed in the solution for some hours or overnight, after which it is taken out, brushed and rinsed in water. If the treatment is incomplete, the process is repeated. The specimen is washed and impregnated. A solution of 1 part each of tartaric acid and caustic soda in 10 parts of water may also be used instead of the alkaline rochelle salt solution.

This method is admirably suited for objects exhibiting slight corrosion. The safety of this method depends upon the fact that while it may attack and dissolve cupric oxide and the compounds derived from it, it leaves unchanged both cuprous oxide and metallic copper.

In cases of considerable corrosion the object is alternately treated in dilute sulphuric acid (5 parts of strong acid to 95 parts of water) and alkaline rochelle salt. The time of immersion in sulphuric acid may range from a few minutes to several hours but is usually very short. If the cleaning is to be interrupted for any reason, for instance at night, the object should be left in the rochelle salt bath and not in the acid. Further the final treatment should always be in rochelle salt.

(ii) *Sodium sesquicarbonate*: (*commercially known as concentrated soda crystals*).—This method is of special value in treating gilt bronzes. A cold or slightly warm dilute solution (5 per cent) can be used. When the gold is loosely adherent, shaking must be avoided and it may be necessary to use a syphon when changing the solution. Dr. Alexander Scott strongly recommends this reagent for treating specimens suffering from "bronze disease" and for curing them without destroying the patina. The specimen is left in a strong solution (either cold or hot) of sodium sesquicarbonate (20) parts by weight to 100 parts by volume of water) as long as chlorine is being removed from the incrustation (test with silver nitrate). The object is then well washed, dried and impregnated.

Isolated spots on large bronzes can be treated by applying to each spot paper pulp charged with 10 per cent sesquicarbonate solution. Repeated application may be necessary.

(iii) *Sodium metaphosphate.*—This reagent has the property of forming stable soluble complexes with calcium and magnesium ions, i.e., calcium and magnesium salts are soluble in it. This property makes it an excellent substance for removing the calcareous dirt with which buried objects are frequently coated. Objects with a good patina have been succesfully cleaned of foreign dirt, leaving the surface otherwise practically untouched. This is done by prolonged soaking in a 5 per cent solution of sodium metaphosphate or by a shorter soaking in a hot 10—15 per cent solution. The object is removed from the solution now and then and the softened lime deposit brushed off.

(2) Silver.—Silver is a soft metal and is not well adapted to the wear and tear of daily use. This softness is overcome to a large extent for coinage and other purposes by alloying it with copper.

The products of corrosion on ancient silver alloys consist of silver chloride, silver sub-chloride, silver sulphide and compounds of copper derived from the copper alloyed with silver. Silver chloride is produced by the sodium chloride dissolved in the sub-soil water which acts in conjunction with oxygen and carbonic acid. The sub-chloride is formed by the decomposition of the normal chloride of

silver by the action of light and organic matter. Black silver sulphide is formed by the continuous contact of the object with decaying organic substances which have contained sulphur.

Ancient silver objects vary very much in their state of preservation. Sometimes the objects suffer only a slight surface tarnish (grey or black); in other cases the objects are covered with a thick green crust and have been mistaken for bronzes.

The use of warm formic acid in various strengths for cleaning all kinds of siver alloys has given excellent results. The object is kept immersed in warm formic acid (10 per cent) for about an hour, taken out, rinsed in water and well brushed with a brush not hard enough to scratch it. If the object is not clean, the experiment is repeated. If necessary the strength of the acid may be increased up to 25 per cent. After cleaning, the object is thoroughly washed and dried.

In some cases where the above method is not satisfactory, the object can be alternately treated in formic acid (10—25 per cent) and dilute ammonia solution (20 parts of strong ammonia of sp. gr. 0·88 to 80 parts of water). [Caution: Strong ammonia causes blisters on the skin.] In using ammonia it must be borne in mind that although it has almost no corrosive action on silver, it attacks and dissolves copper. So this method is not safe for objects of thin metallic base silver as it may increase their natural fragility by extracting the copper. The object is given a coating of vinyl acetate or celluloid.

(3) Iron.—Iron objects are very susceptible to outside agencies and deteriorate more rapidly than other metals. Iron containing little carbon (wrought iron) rusts with greater ease than iron which is rich in carbon (cast iron or steel). The agents responsible for the rusting of iron are: (*a*) moisture, without which rusting is impossible, (*b*) common salt derived from the earth and (*c*) oxygen and carbon dioxide from the air.

The condition of the objects differs widely. "The rust may be uniform in colour and hardness in one case and in another, soft areas, generally light in colour, may alternate with darker patches, etc." Sometimes the specimen is only a mass of iron oxide. In highly corroded iron objects, the rusted surface contains small brownish moist beads consisting of chlorine compounds of iron surrounded and permeated with oxides.

A satisfactory method in many cases is to boil the object in 10 per cent caustic soda solution. The solution is repeatedly changed till the chlorides are completely eliminated. Lumps of lime incrustation can be removed by subjecting the object to dilute nitric acid prior to treatment with caustic soda. For removing the softened incrustation only soft iron brushes should be used (not brass, as it leaves an yellow colour).

The object is washed thoroughly in water, quickly dried and impregnated with 2 coats of paraffin wax in benzene (5 per cent). Shellac varnish may also be used. The object can also be impregnated by immersing it in hot molten paraffin wax. This method can be used in the case of highly corroded objects containing little or no metallic core.

In case there is a strong metallic core left behind, the specimen can be reduced with zinc and caustic soda. (See electrochemical method under copper and bronze.) In this method zinc oxide, a white powder, is deposited on the iron to some extent. This is removed by washing the object in dilute sulphuric acid. The object is finally boiled in fresh caustic soda solution (10 per cent), washed in running water, quickly dried and impregnated.

(4) **Lead.**—Notwithstanding the general inactivity of metallic lead, antique objects of lead are usually covered with a white incrustation, consisting mainly of a basic carbonate of lead mixed with a little oxide. In some cases the incrustation also contains a little lead chloride.

If the corrosion is slight, the object is painted over repeatedly with dilute acetic acid (10 parts of strong acid to 90 parts of water) by means of a brush. If the object is highly corroded, it is soaked in the dilute acid, taken out at intervals and brushed. (When cleaning lead objects, it should not be forgotten how very soft and easily marked the metal is. It must also be borne in mind that acetic acid is not without action upon metallic lead and that all traces of acid must be completely washed.) The object is then soaked in dilute caustic soda solution (1 per cent) to neutralise the acid. Caustic soda also acts upon lead; therefore the treatment must not be prolonged. The alkali is washed out by hot freshy-boiled distilled water until no free alkali remains, as indicated by the behaviour of phenolphthalein (should remain colourless). The object is dried in a steam oven and taken to a clean atmosphere and allowed to remain there for at least a week so that a uniform protective layer may form. Finally the surface is protected either by varnishing it with vinyl acetate solution (2—3 coats of 2 per cent solution) or by dipping in hot paraffin wax. Celluloid is not recommended for lead since it gives off traces of acid which may prove injurious to specimens. Dammar, shellac or mastic varnish may also be used. (Note that lead objects should not be stored in oak cabinets as the wood gives off traces of volatile acid—to which it owes its peculiar smell—destructive to the metal.)

(5) **Prints, Drawings, etc.**—The chief ailment from which prints and drawing suffer is a discolouration of the paper on which they are executed. Brown and other coloured spots are seen all over the paper. Such a condition is known as 'foxing'. These spots have been usually in some way connected with the growth of mildew and mould or similar organisms. Paper usually contains small quantities of iron, derived, perhaps, in some cases from the vessel

in which the pulp was mixed. "Paper-infesting fungi produce acid from cellulose (of the paper) and this acid attacks the small quantity of iron impurity present in the paper. Organic iron salts are formed and they collect at various centres (according to the conditions of humidity, etc.), where they eventually decompose yielding by atmospheric oxidation foxed spots consisting of oxide and hydroxide of iron. Some of the factors having a bearing on the question of foxing are the nature of the paper, size, inks and pigments, humidity and the type of fungus. Whatever may be the cause, these marks are highly disfiguring and have to be eradicated to prolong the life of the print and to enhance the aesthetic effect.

Various bleaching processes have been designed to remove the discolouration and the brown spots and to restore to the paper the original tint. An active agent, like oxygen or chlorine, is made use of to oxidise the colouring substances (that make up the stains) to produce colourless or less strongly coloured ones. Such bleaching processes in themselves are easy operations but when one is dealing with prints and pictures, there is the question of attaining satisfactory results without loss of brilliancy in the inks or pigments. The nature of the picture and the stains should determine the best kind of treatment, and experience is here of utmost value.

(*a*) *Bleaching Processes*—(i) *Exposure to sunlight.*—Any loose surface dirt is removed by means of a soft dry brush. (Dirt may also be removed by means of a piece of bread, worked into a kind of ball, by going over the surface of the print in a series of circles.) The print is placed in a dish of water and exposed to strong sunlight for several hours. When free from discolouration, the print is removed from the water, blotted repeatedly between fresh sheets of white blotting paper. A piece of cardboard is laid on the blotting paper and a slight weight placed over it until the print is dry. This method has given good results in the case of Egyptian Papri where the writing material is a stable carbon ink.

(ii) *Bleaching Powder—Hydrochloric Acid.*—In this method 'foxed' marks are removed with dilute acid and a weak solution of bleaching powder used alternately, followed by extensive washing.

After removing the surface dirt, the print is immersed, face upwards for about 10 minutes in a 1 per cent solution of hydrochloric acid (made by diluting strong acid of sp. gr. 1·16 with 30 times its volume of water), then transferred without washing for another 10 minutes to a second bath containing a dilute solution of bleaching powder (1 gm. to 100 c.c. of water), then back again to the acid without washing and so on until the discolouration disappears. The print is then washed thoroughly 'with something of the ritual of the photographic studio'. It is immersed in a tray of clean water and the tray rocked gently causing the water to travel back and forth. The water is repeatedly changed until the washings are free from chlorides (test with silver nitrate) and from acid (test with litmus). This may take an hour or two. The print is then dried between blotting papers.

This method is applicable only in cases where the basis of the picture is carbon in some form or other. Printing ink is composed of carbon containing a binding material like linseed oil, and so printed matter can be safely treated by this method. With a little precaution, pencil drawings can also be treated, for, although there is no binding medium, the graphite (graphite is also a variety of carbon and so is permanent) particles become fixed, in time, to the paper. Any writing in iron gall ink will disappear unless it is protected beforehand. This is done by the local application of a solution of celluloid (2—3 coats of 5 per cent solution). It may be removed afterwards when the print is dry by a wash of acetone.

(iii) *Hydrogen Peroxide.*—The advantage of hydrogen peroxide lies in the fact that the products of decomposition are just oxygen and water, eliminating the necessity for prolonged washing. For use, a mixture is made of hydrogen peroxide solution (10 vols.) and water in equal proportions in which the print is immersed until clear, when it is taken out, washed and dried. Hydrogen peroxide is not very quick in its action, and in some cases it may be necessary to leave the print in the bath overnight.

Where the presence of water is undesirable, as in the case of water colour paintings, hydrogen peroxide vapour can be used. A flat block of stucco plate is prepared and dried. A small quantity of a concentrated solution of hydrogen peroxide is distributed as uniformly as possible over the surface of the block. The print is placed, face downwards, at a distance of an eighth of an inch or so and the hydrogeon peroxide vapour which comes off gradually acts on the picture and not only removes the spots but also brightens up the pigments. In many coloured pictures, white lead is freely used. These whitened parts in time become discoloured and finally quite black owing to the conversion of white lead into the black lead sulphide. Hydrogen peroxide oxidises the lead sulphide to the white lead sulphate and the pigment regains its warm original tone.

Another method of applying hydrogen peroxide is in alcoholic solution, equal quantities of hydrogen peroxide solution and absolute alcohol being mixed and painted on the discoloured spots with a soft brush.

(iv) *Chloramine T.*—This reagent has been recommended by Dr. Plenderleith of the British Museum. It is a white, rather insoluble powder and must be kept in a well-stoppered bottle on account of its instability. A 2 per cent solution (2 gm. in 100 c.c. of water) is prepared as and when required. The solution is applied to the spots with a soft brush. The drawing is then covered with blotting paper and placed under a glass plate. The result is examined after an hour and the treatment repeated if necessary. Chloramine T as a bleach has the advantage of not having to be washed. This process is particularly suitable for water-colour drawing as the reagent may be applied to those parts of the work which are stained without endangering the whole.

(*b*) *Removal of Stains.*—Besides discolouration by mildew, prints may be accidentally stained in other ways. Oil and grease stains are a common source of trouble. Petrol is effective in removing wax and candle grease stains. The print is immersed in a bath of pure petrol preferably face downwards and the back brushed gently from time to time with a soft brush. If the stain is persistent, acetone and benzene can be tried. For the removal of oxidised oils, asphaltic stains, paints and varnishes, pyridine has been found to be very effective. This is applied by means of a brush of glass fibre and the liquid after a short time removed by pure white blotting paper. The application is repeated.

(*c*) *Fumigation.*—In addition to the restorative treatment, there are certain types of treatment for paper that have a largely preventive value. Fumigation is one of these and is done to destroy any mould or bacterial growth or to kill spores before they develop. With a few exceptions, prints, drawings, manuscripts and water-colour paintaings can be sterilised by means of thymol vapour.

The picture is placed in a tray inside a fairly air-tight box, preferably above a large clock glass containing about 10 gms. of thymol crystals. If a little heat is applied (e.g., by switching on for a short time an ordinary electric lamp fixed some two inches below the clock glass), the thymol readily melts as its melting point is 44°C and soon the air inside the box becomes saturated with the vapour. The period of sterilisation may range from three or four hours to anything upwards depending upon the degree of infestation.

Carbon-di-sulphide which is a very effective insecticide has also been used in some cases. However, it possesses the disadvantage of being highly inflammable. When mixed with air in certain proportions, it is explosive. It has an exceedingly unpleasant smell, too. A mixture of ethylene-dilchoride (3 parts by volume) and carbon tetrachloride (1 part by volume) is another effective reagent. These are liquids that on exposure to the air evaporate forming gases which are effective insecticides. This mixture is non-explosive and non-inflammable.

(6) **Bone and Ivory.**—Bone and ivory have been used from ancient times for many purposes—purely utilitarian as well as decorative. Being organic materials, they present peculiar problems in conservation. Both are made up of calcium phosphate and calcium fluoride and ossein, an organic material. Ivory is more compact than bone.

Generally old bone and ivory are found warped and brittle due to the action of heat and moisture. Being light of colour, they also get easily stained. When buried underground for long, they tend to get weakened by salt incrustation or water which decomposes the organic material in them.

When the bone or ivory object is in a fairly good condition, it may be cleaned with water and either soap or a detergent. It must not be allowed to be in contact with water longer than necessary. After washing off the soap with distilled water, the object is dried with a soft towel. If the ivory or bone is partially decayed, the final drying has to be done by passing it two or three times through 95 per cent alcohol.

When the objects are covered with carbonate incrustation, the conservation is more complicated. The use of acid to decompose the carbonate is essential but it has to be done without letting the effervescent carbon dioxide disintegrate the object. J. Franklin Ewing used the following formula successfully for specimens of bone recovered from limestone breccia :

Glacial acetic acid	60 c.c. dissolved in
Water	1 litre ; to this
Saturated sodium hydroxide solution.	10 c.c. is added.

The action of this solution upon the crust was slow. Unprotected bone is, however, not to be exposed for more than 3 or 4 hours. The bone may safely be protected from the acid by being impregnated with a thin solution of Alvar*. It was also found that two coatings of a chlorinated rubber varnish afforded adequate protection even against strong hydrochloric acid. In such a case, the crust was decomposed by the acid dropped on to it with a pipette. Every time the removal of the crust exposes the bone, fresh coatings of the rubber varnish have to be given. After the acid treatment renders the crust porous and soft, it can be removed by gentle mechanical means like careful picking with a needle.

After restoration, bone or ivory must be dried by exposing the object to air in a dry place. Heat should never be used. Impregnation of ivory or bone may be done with a solution of vinyl acetate in toluene (15 per cent). Durofix may be safely used for repairing broken fragments.

Resins, Waxes, Drying Oils, etc.—Various resins, both natural and synthetic, drying oils and other organic substances like paraffin wax, beeswax and glue have been extensively used in the restoration of museum exhibits. They have been used for a variety of purposes :—(*a*) as preservative coatings to protect the objects from external influences (dirt, moisture, acid, fumes, etc.), (*b*) for consolidation and strengthening of fragile objects, (*c*) for fixing craked and scaling paint films on paintings, (*d*) as cements in joining broken pieces, etc.

Among the most promising of these have been :—mastic, shellac, dammar, canada balsam, copal, isinglass, sandarac, chlorinated rubber, linseed oil, celluloid, cellulose acetate, polyvinyl acetate and waterglass.

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* Manufactured by Shawinigan Products Company, Limited, Shawinigan Falls P.Q., Canada, or Empire State Building, New York, United States of America.

In choosing the proper substance and the solvent, various factors have to be taken into consideration—(*a*) the adhesiveness, elasticity and toughness of the lacquer films, (*b*) transparency of the film, (*c*) chemical inertness, (*d*) resistance to weathering, (*e*) moisture-proofness, (*f*) power of penetration of the lacquer solution, (*g*) cost of the substance and the solvent, (*h*) rate of evaporation of the solvent.

Vinyl acetate, for example, is superior to many other substances on account of its water-white transparency. The polyvinyl resin is more elastic and less inclined to embrittle and peel than celluloid film. But the films produced by most of the artificial resins are permeable to water vapour and they are not to be chosen where protection from moisture is the first consideration. In this respect they are inferior to substances like beeswax. The colour of beeswax is a disadvantage when treating some of the white or light-coloured materials and in such cases paraffin wax is used. Also paraffin wax is safer than beeswax in being chemically more inert. The former is only a mixture of saturated hydrocarbons while the latter contains some acids. But the film formed from paraffin is not so elastic as the one from beeswax. Cellulose acetate is a more stable compound than celluloid and so is preferred in strengthening woven fabrics. Celluloid may eventually develop some slight acidity and old fabrics are very susceptible to traces of acids.

The rate of evaporation of a liquid is also a very important factor when it is used in a lacquer formula. Rapidly evaporating solvents are liable to cause a blush, and to overcome this, high-boiling liquids are added. Celluloid is dissolved, for this reason, in a mixed solvent of acetone and amyl acetate. Various specific formulae have been suggested for these lacquers but it is best to prepare one's own depending upon requirements. Some among the many solvents used for this purpose are: benzene, toluene, alcohol, acetone, amyl acetate, ethylene dichloride, petrol, turpentine, ether and carbon-di-sulphide. The usual strengths of these solutions range from two to five per cent.

APPENDIX A.

LIST OF CHEMICALS AND MATERIALS EMPLOYED IN CHEMICAL RESTORATIVE AND PRESERVATIVE WORK.

Acetic acid (Glacial).—It is a corrosive organic acid with a m.p. of 16·7°C and b.p. 118°C; sp. gr. 1·05. Both the "pure acid" (i.e., glacial) and liquids containing various percentages of acid (40 per cent, 80 per cent, etc.), are available in the market; the acid is soluble in water and alcohol.

Acetone.—Colourless organic liquid belonging to the group of compounds known as "ketones". b.p. 56·5°C, sp. gr. 0·79. A good solvent of celluloid.

Alcohol.—The term is generally understood to signify spirits of wine of various strength. *Absolute alcohol* (same as ethyl alcohol) is alcohol without any water, but as it absorbs water from the atmosphere, the strength of commercial absolute alcohol rarely exceeds 98 per cent. Rectified spirits are spirits rendered pure and strong by redistillation (about 95 per cent strong).

Ammonia.—It is used as a washing agent for neutralizing any acid that might have formed on a mineral.

Ammonium Phosphate.—It is a good fire-proofng material for wood.

Amyl Acetate.—Colourless organic liquid with an aromatic smell. Sp gr. 0·875°, b.p. 140°C—148°C. There are three varieties of amyl acetate of which "common amyl acetate", is the compound "iso-amyl actetate". Used as a solvent of cellulose; used along with acetone for preparing celluloid varnish, cement, etc.

Ascu.—This is the trade name given to a preparation containing copper, arsenic and chromium salts in the proportions which are most resistant to bleaching. It is extensively used as a wood preservative.

Beeswax.—It is a yellow, tough solid of complex composition. Melting point ranges from 60°C; soluble in ether and chloroform.

Benzene (Benzol).—A colourless, inflammable organic liquid with a b.p. of 80°C; an excellent solvent of resin, fats, etc.

Benzine (Petrol, Petroleum spirit).—Benzine is not synonymous with benzene. The name is given to a light petroleum oil boiling between 120°—150°C.

Bibulous paper.—It is one which is capable of absorbing moisture. Any paper possessing this property, can be used in drying plants.

Bleaching powder (also known as the "chloride of lime").—It is a white powder containing 35—40 per cent of available chlorine. As its name indicates, it is used for bleaching, for example, paper, textiles, etc.

Calcium Hydrate.—It is also known as Calcium Hydroxide.

Calico.—It is sold as cloth or as paper. The latter is easier to work with.

Camel Hair Brush.—It is sold in various sizes. Size No. 4 and size No. 1 will be useful.

Canada Balsam.—It is a resin obtained from certain fir trees in Canada. It is soluble in xylol and benzol.

Carbon Tetrachloride.—It is employed in fumigation, when mixed with ethylene-dichloride in the ratio of 1 : 3.

Caustic Potash (chemical name : potassium hydroxide).—White deliquescent and caustic substance. When it is dissolved in water, great heat is produced. (cf. Caustic soda.)

Caustic Soda (chemical name : sodium hydroxide).—White, highly deliquescent, caustic substance. Marketed in several forms—flakes, sticks, pellets, etc. Much heat is evolved when it is dissolved in water. (cf. Caustic potash.)

Celluloid.—Good, transparent sheets are available in the market. Old photographic films may also be used, though this is not advisable when dealing with works of art. The sheets are cut in bits and dissolved in equal parts of acetone and amyl acetate. "Celluloid cement" consists of celluloid dissolved in a suitable solvent (acetone) to give a thick syrupy liquid (about 10 per cent).

Cellulose Acetate.—A non-inflammable substance. Soluble in acetone giving a solution which can be used for preservative coatings. It is a more stable compound than celluloid and so is superior to celluloid solutions for treating old fabrics.

Chiffon.—It is a fine, almost transparent, silk gauze.

Chloral-hydrate.—Crystalline substance with a melting point of 57°C. Soluble in water and alcohol.

Chloramine-T.—A dull white substance; capable of generating chlorine; must be kept in a well-stoppered bottle.

Chloroform.—A volatile, anaesthetic liquid; b. p. 60°C. Good solvent for fat and other substances.

Clay.—Fine-grained kaolin, which should not crack when dried, is used for purposes of modelling.

Corrosive Sublimate (chemically known as mercuric chloride).—It is a highly virulent poison. If any metal is allowed to come in contact with it, the solution not only gets itself stained but also stains the specimens.

Ether.—It is highly volatile and inflammable.

Ethylene Dichloride.—It is employed in fumigation mixed with carbon tetra-chloride in the ratio of 3 : 1.

Forceps.—These are of various sizes. It is better to possess a pair about one foot long; and another about six inches long. That with a sliding button to keep the two arms closer will be very helpful. It will also be advantageous to possess in addition to these a pair of small forceps with slightly curved tips.

Formalin.—A commercial aqueous solution containing 40 per cent of the compound "formaldehyde".

Formic Acid.—When pure, it is a colourless liquid which boils at 101°C. It is a powerful antiseptic, very corrosive, and mixes with water in all proportions. Solutions of various strengths (50 per cent, 25 per cent, etc.), are available in the market.

Fret saw.—It is a light steel frame holding thin saw-blades of varying grades of fineness, which can be removed or changed at will.

Glue.—It is an impure form of gelatin and a good adhesive for wood. Fish glue which is commonly sold is unsatisfactory. Quality glue should be of a light colour and free from smell. It is prepared for use by breaking it into pieces and soaking in cold water till the pieces become soft and swollen. The excess water is poured off, and the substance is heated in a glue pot, below 80°. The glue is applied with a brush when it is hot.

Hydrochloric acid(Conc.).—The commercial concentrated acid with a sp. gr. of 1·18 is an aqueous solution of 30 per cent strength. The acid must be carefully handled (when diluting, etc.); the vapour has a pungent and irritating effect.

Hydrogen Peroxide.—It is an odourless and colourless liquid like water. On decomposition it gives water and oxygen. Solutions of hydrogen peroxide in water are used for bleaching straw, hair, etc. It is marketed in various strengths ".10 volumes", "20 volumes", etc. A 10-volume solution means that on decomposition it will yield 10 times its volume of oxygen; on chemical calculation, this works out to 3 per cent approximately.

Menthol.—A colourless crystalline substance with a m.pt. of 40°C.

Methylated spirits.—A mixture of alcohol denatured with other substances such as pyridine, naphtha, benzine, etc., to render it unfit for consumption but yet available for chemical purposes.

Naphthalene.—It is used for keeping off the insects. It, however, does not confer more than a limited protection against certain kinds of insects.

Nitric acid (Conc.).—Colourless, strongly-fuming, corrosive liquid, which attacks many metals with avidity forming nitrates. Also a strong oxidising agent. The usual commercial concentrated acid with a sp. gr. of 1·414 contains about 68 per cent of nitric acid by weight. The acid must be carefully handled while diluting, etc.

Para-dichloro-benzene.—White crystalline solid with a m. p. of 43°C. Used as an insecticide.

Paraffin wax.—White, translucent mixture of hydrocarbons with m.p. 60—65°C. Soluble in turpentine, benezene, chloroform, etc.

Passe partout.—It is a kind of ribbon, sold by the photographic companies, and is of immense use in making glass boxes, preparing specimens for display, etc.

Petri dish.—It is a wide, circular, shallow glass cistern with a flat bottom.

Plaster of Paris.—Plaster of Paris is calcium sulphate which has been deprived of part of its water of combination by heat. It has a great tendency for recombining with more water, with which it sets into a hard mass. A slight expansion occurs during setting so that it will take a sharp impression of a mould, and so is used in making casts. Admixture of alum, borax, etc., with the plaster reduces the rate of setting while common salt, etc., accelerate it. Generally any hastening of the setting is unnecessary.

Plasticine.—It is a soft, clay-like plastic material that does not stick to the hands. It is very useful for making models in a laboratory.

Polyvinyl Acetate.—It is a good and reliable varnishing material for unstable minerals. For use it is dissolved in a mixture of equal parts of toluene and acetone.

Potassium Cyanide.—White deliquescent, crystalline salt of *very poisonous* character.

Pyridine.—A practically colourless liquid of penetrating, sharp odour with a b.p. of 115°C.

Quicklime.—It is also known as calcium oxide. It is capable of absorption of moisture in the air.

Rochelle Salt (Sodium Potassium Tartrate).—Colourless, crystalline compound soluble in water.

Sawdust.—That obtained from cedar-wood should be preferred. The finer the grains, the better.

Shellac.—A resinous excretion of the lac insect. Shellac varnish consists of the resin dissolved in alcohol.

Stockholm Tar.—It is also sold as Pix liquida.

Sulphuric acid (Conc.).—Colourless, oily liquid, without odour. Extremely corrosive to the skin and all body tissues, and so causes very serious burns. The commercial concentrated acid, with a sp. gr. of 1·84, contains about 98 per cent sulphuric acid. On mixing sulphuric acid with water, the mixture becomes hot and the temperature may rise as high as 120°C. This is liable to cause serious accidents if care be not taken when diluting the acid. The acid should always be added to the water with vigorous stirring. *Under no circumstance should water be added to the strong acid.*

Thymol.—White crystalline substance of mild, pleasant odour with a m.p. of 44°C. Used as an insecticide.

Tissue paper.—It is a thin, soft, unsized paper used for protecting delicate objects.

Turpentine.—Oil of turpentine is a mixture of hydrocarbons produced by nature in pine trees. A colourless mobile fluid with a characteristic odour soluble in alcohol and ether. The property of turpentine of dissolving resinous and fatty substances renders it exceedingly useful in the preparation of paints and varnishes and for the removal of such substances from fabrics. When oil of turpentine is exposed to the air, it slowly becomes solid, absorbing oxygen.

Varnish.—It is of two varieties, spirit varnish and oil varnish. It is the former variety that is used for timber.

White Arsenic (also known as arsenious oxide).—In commerce it is also sometimes called simply " arsenic ". It is used as an insecticide and for rat poison; used in preserving the skins of animals. Arsenious oxide is very poisonous as are also most of the arsenical compounds.

Xylene (also called xylol).—There are three kinds of xylene—the ortho, para and meta varieties with b.ps. of 142°C, 138°C and 139°C respectively. The commercial product is a mixture. Colourless liquid with a faint odour distinct from that of benzene.

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APPENDIX C.

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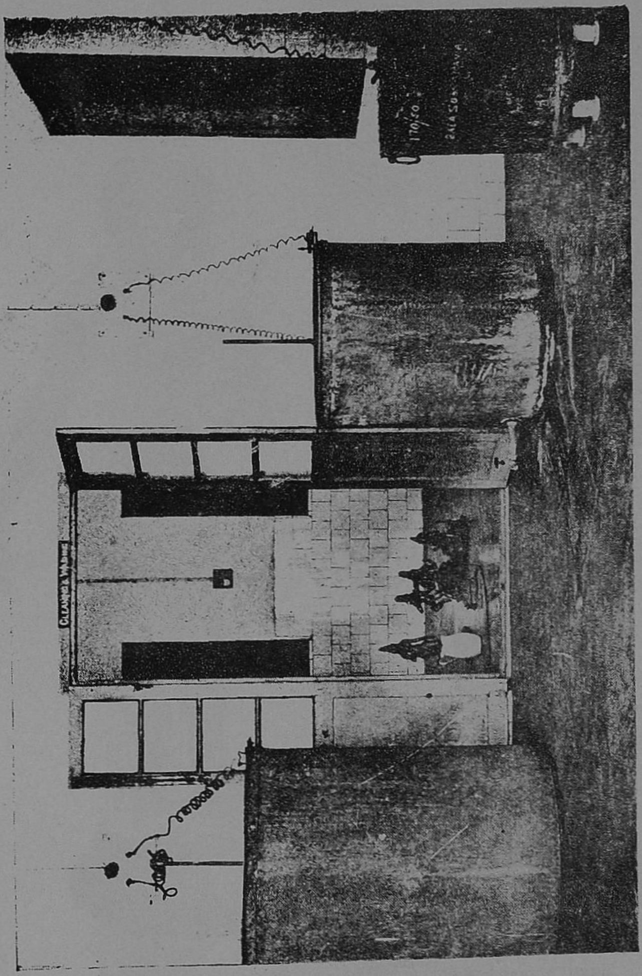
PLATE VIII



ELECTROLYTIC CELLS IN THE MADRAS GOVERNMENT MUSEUM.
The electrolytic restoration of bronzes is carried out in these cells.

PLATE IX

BEFORE TREATMENT. AFTER TREATMENT.

A bronze image before and after electrolytic treatment.

PLATE X

Som · silver punch-marked c·ins from the Amaravati hoard (found in Amaravati village, Guntur district) *before treatment.*

PLATE XI

Some silver punch-marked coins from the same Amaravati hoard *after treatment.*

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